EMCEngineer

User Guide

Issue 5 08/96

LAPLACE INSTRUMENTS LTD

WARNING

EMC emissions measurements and the use of RF spectrum analysers require specialist expertise and users must be aware of several 'non-obvious' precautions. Unless you are already familiar with these specific topics it is most important to read this instruction manual fully before using the equipment otherwise erroneous or misleading results many be obtained.

You have been warned!

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1.0 Specification

SA450B

Frequency range	10KHz - 450MHz
Sensitivity	better than -80dBm (27dBuV)
Max. RF input (50R)	3dBm (110dBuV)
Input protection	Diode clamped, 1.6V pk-pk max.
Hi Z input impedance	50K
Max. RF in to Hi Z input	30V rms
Bandwidth - narrow	9KHz
- wide	120KHz
X scan/div Lo freq. range	Off, 1, 5, 10, 50, 100, 500 KHz
Plus for Hi freq. range	1, 5, 10, 20, 50 MHz
Input dynamic range	50dB typical
RF attenuator	-20dB
Scan centre frequency	3 digit display
Input power	230V 50Hz, 40W
Factory set option	115V 60Hz.
Physical	
Dimensions	305 wide x 270 deep x 115 mm
Weight	5kg

SA1020

Bandwidth (nom 3dB points)	10KHz - 500MHz
Gain	18dB
Gain accuracy	±3dB for above Bandwidth
Noise*	3dB (degradation of S/N Ratio)
Max. safe input	0dBm (220mV)
Input impedance	50R
Max. Output into 50R	0.5 volt pk-pk
Output impedance	50R
Power	9V PP3 battery
Consumption	20mA

Physical: Size	115 x 107 x 50mm (over connectors and switch)
Weight	200 grams (including battery)
Connectors	50ohm BNC

* typical

SA1030 Computer interface and software

Comprises:	Adaptor unit, DOS and Windows software	
Adaptor unit:	Input:	Direct from SA450B via rear panel
	Output:	RS232 Serial port, compatible with PC standard.
	Power:	Derived from SA450B
	Function:	Spectral data transfer to PC
Software:		
Compatibility: DOS version:		Any standard PC with min.VGA screen
Windows version:		Any PC running Windows.
Functions:		Spectral display 10KHz - 500MHz
		Average, peak and Quasi-peak calculation
		Difference of spectra (background nulling)
		Limit line display*
		Antenna Factor correction*
		Antenna distance correction*
		Log/Lin frequency axis*
		Data storage to disk and recall
		Output to printers

Note: * indicates Windows version only

RF100

H field loop antenna	
Type:	Balanced faraday loop
Diameter:	50mm
Sensitivity:	See graph enclosed with probes
E field antenna	
Type:	Monopole
Monopole length:	10mm
Sensitivity:	See graph enclosed with probes
Overall length:	250mm
Common specifications	
Insulation rating:	240v
Connector:	50R BNC

RF200

Frequency range:	30MHz - 1GHz.
Antenna Factor:	Similar to tuned dipole.
	Curve issued with each antenna.
	Data pre-loaded into EMCEngineer software supplied with Laplace EMC kits
Calibration:	Tested at NPL free space antenna test facility.
Ancillaries:	SA1020 Pre-amplifier.
Type:	Modified Log periodic.
Size:	Length 1.7m.
	Max. width 1.6m.

Stand:	
Construction	Tubular Fibreglass/epoxy supports and moulded plastic fittings.
Adjustable Height:	1.1m to 2.1m.
Antenna orientation:	Vertical or Horizontal

RF500

Antenna Type:	Tuned Dipole
Tuned Freq. Range:	80MHz - 265MHz
Adjustment:	Telescopic
Output:	50R BNC
Stand:	Tubular steel, adjustable.

LISN1600

Max current:	16A continuous
Max Voltage:	264V, AC to 70Hz
LF Resistance:	135 mohm
Impedance Network:	to CISPR16
I/P Imp. Variation:	±20% 9KHz-30MHz (CISPR Spec.)
Measurement cct.	
Attenuation:	-0.5dB Nom. Calibration factor
	-5dB at 9KHz (to CISPR Spec)
	±0.3dB variation 150KHz - 30MHz
	+0.5/-1.0dB variation 30-100MHz
Source selection:	Line 1 (L), Line 2 (N), OFF
150KHz HP filter:	-40dB at 50hz, -0.2dB at 150KHz
Output Connector:	50R BNC
Artifical hand:	220pF + 500R

Physical:	Weight:	6.5kg
	Size(mm):	132(H) x 212(W) x 315(L)

2.0 Introduction

The introduction of legislation requiring the measurement of RF emissions from all products sold within the EC so as to ensure that they comply with specified limits highlighted the lack of facilities in Europe for conducting these measurements. Conventional equipment was expensive and test house facilities limited. A handful of manufacturers introduced low cost measurement equipment to bring EMC testing within the realistic budgets of most potential users. In order to keep costs down, accuracy is not up to test house standards. However it has since become clear that the integrity of EMC test results depends more on the test conditions (test site, background radiation etc...) than on the test equipment. Therefore, provided the test environment is suitable, users can and do use this type of test equipment for self certification without resorting to test house visits.
The RF-Kxx kits have been designed specifically for EMC measurements, both radiated and conducted.
These kits at the very least enable the user to minimise and control the use of expensive test houses.

Budget test kits can:
(a) Provide relatively accurate mains conducted emissions measurements.
(b) Provide the means by which you can 'see' problem emissions and locate sources and leakage paths
(c) Make relative measurements of far field emission levels and identify potentially problem frequencies.
(d) Provide the capability for comparative measurements. These may be before/after checks when circuit or screening refinements are being tested, testing one product against another, measuring the effectiveness of sceening, checking production units for consistency and trend.
(e) Help ensure that a product is as good (EMC-wise) as possible before submitting it to a test house, thus maximising the chances of passing first time.
(f) Calibration of your own test site by using a reference source. This will enable you to test products on your test site with some degree of confidence and may provide adequate information to justify self-certification without further use of test houses.
(g) Provide a facility to perform relative tests such as insertion loss tests as required by EN55 015 Because these test do not require measurement of field strengths, the results are dependable.
(h) Perform production testing on a go/no go basis. The standards require testing of all products as they leave the production line so as to ensure that the EMC performance does not significantly change from that measured on the unit used for the initial qualification approval testing.

The Laplace RF-Kxx range of EMC test kits may not altogether replace the use of test houses, but they certainly will repay their cost many times over in saved test house bills, reduced project timescales and improved product performance. In addition, by testing in-house, your engineering team will gain useful experience in EMC control techniques which may result in shorter project timescales and costs on future products.

3.0 Packing list

Check that all the items relevant to the kit specified on your order are included in the delivery. If any parts are missing, contact your supplier immediately.

All kits	*RF-K...*
SA450B	**4**
SA1020 with PP3 battery	**4**
SA1030 interface unit	**4**
Serial lead (9 pin dee connectors)	**4**
Short 15 way ribbon cable	**4**
RF100 E and H field probes	**4**
RF200 or RF500 antenna with stand	**4**
EMCE software (3½" disk)	**4**
User manual	**4**
Qty 3 BNC-BNC leads	**4**
Mains lead (UK only)	**4**
EMC for Product Designers (Book)	**4**
BNC male-male adapter	**4**

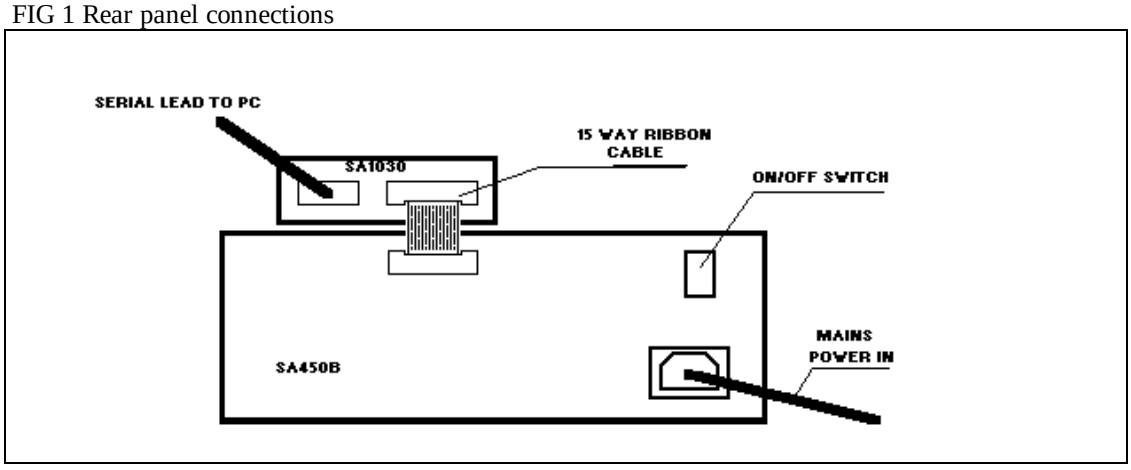
Options	*...2*	*...4*	*...6*	*...B*	*...C*	*...A*	*...L*
No LISN	**4**						
With 16A LISN		**4**					
With 150A LISN			**4**				
RF200 in place of RF500				**4**			
ERS reference source					**4**		
RF400 RF Absorbing clamp						**4**	
RF300 Large Loop Antenna							**4**

4.0 Quick start information:

4.1 Setting up.

1. Unpack all items and check against the packing list above to ensure no items are missing.
2. Connect mains lead to analyser and, if using the SA1030 PC interface, connect the 15 way ribbon cable and serial lead as shown below. Install the PC software on the PC as described in section 6.2 or 6.6 1.

FIG 1 Rear panel connections



If using a scope, use BNC leads to connect it to the front panel sockets. See section 5.2.5 on scope settings.

3. Decide whether to use the low frequency (10KHz - 5MHz) range or the high frequency (5MHz - 500MHz) range. This depends on the test you wish to perform. Connect the input lead to the appropriate 50 ohm input socket and set the RANGE switch to the appropriate position.

Basic analyser settings:

Range	**Low frequency**	**High frequency**
Range switch	4.5	450
Scan (MHz/cm)	500KHz	50MHz
Centre frequency	2.5MHz	250MHz
B/width	narrow	wide

Other initial settings are: Audio gain, fully anti-clockwise (off)
Scope sweep rate, full clockwise (fastest)
Input attenuators, in (safest)
Filter; if using 'scope: in, if using PC: out
Baseline fully anti-clockwise, (zero shift)

4. Switch the analyser ON (rear panel). If using a scope and provided that it is set as per section 5.2.5, the display should now show the selected spectrum (0-5MHz or 0-500MHz).

4.2 Software Operation

NOTE! The main controls for the whole system are those on the RF analyser. The PC/software does NOT control the analyser, nor will the PC read the switch settings on the analyser.

ALWAYS control the system using the analyser controls and then set the PC settings to correspond.

Refer to the software section 6 for additional information.

1. Run the EMCE software
2. Select Port menu from the top of the screen.
3. Select either Com 1 or Com 2 appropriate to the serial port you have used for the connection to the analyser. Deselect 'Port has priority'
4. Click on the RUN button at the bottom of the screen to check operation. You should see on the display area a trace corresponding to the settings and inputs on the analyser. Disconnect any inputs to the analyser and you should see a trace along the bottom of the screen, flickering slightly as the screen refreshes. Just to the left edge of the screen there may be one large peak in the view. This will be the 'zero frequency' peak. For explanation see section.5.1.1. Check the correct settings by adjusting the Centre Frequency controls on the analyser until this zero peak is just moved to the centre of the screen. Check that the digital display on the analyser reads zero. Adjust the centre frequency back to 2.5 or 250MHz (Low or High freq. Range) and the zero peak should just reach or slightly overshoot the left hand endge.
5. Reconnect the input to the analyser.

4.3 Radiated emissions:

1. Connect an antenna (RF200, RF300, RF400 or RF500) via the SA1020 pre-amplifier to the 5 - 450MHz input.
2. Install a battery in the SA1020. Note that the SA1020 is supplied with a battery, located in the battery compartment. Ensure this battery is unwrapped and connected to the battery leads.
3. Orientate the antenna to suit, place it about 3 metres from the product and switch the pre-amplifier ON. Leave the UUT switched off.
4. The screen should now show the background radiation as received by the antenna, plotted as amplitude vs frequency.
5. The signal strength must be checked to ensure that the analyser is not overloaded or driven into compression. Ensure the input attenuator is still switched IN. Check the height of the dominant

peaks. Switch the input attenuator out and check that the dominant peaks move up by 2 divisions (20dB) If the change is less than 15dB, the analyser is being driven into compression and a 'quieter' location should be found for EMC testing. Note: see section 8.6 for alternative means of overcoming rogue peaks or use the RF400 RF absorbing clamp. For serious EMC testing, the attenuator switch must be OUT.

6. If outdoors or in a relatively unscreened indoor area, the FM transmissions between 86 - 108MHz may be clearly seen as a cluster of peaks. To confirm, tune these peaks to centre screen using the centre frequency controls on the analyser, gradually home in on a selected peak by reducing the scan mode (MHz/cm) setting and adjusting the centre frequency control to keep it on screen. The accurate frequency of the transmission can be read off the SA450B digital display and the nature of the transmission confirmed by turning up the audio control. Switching the Scan Mode switch to OFF should result in a clear audio signal. Set the analyser back to the original settings (ie 50MHz/div and 250MHz centre screen) before continuing.

7. The presence of emissions from a product can be crudely tested by switching the product on/off in the vicinity of the antenna. If there are any 'heavy' emissions, these will show up as changes in the spectrum. In general, emissions from most products are minimal and to 'see' these amongst the background, a more sophisticated approach is required to null out the background.

8. Because the background is generally unstable, switch the UUT off and select averaging = 16 from the Calculate menu. This will cause consecutive spectra to be averaged together. After 16 screen refreshes, the screen should now show a more stable result. Copy this result to the STORE trace by clicking on the C>S button. If the stored (red) trace is turned on it should be virtually identical to the current (black) trace.

9. Turn the diff trace on and the current and stored traces off. The screen will now show any increases in signal received over the stored background trace. If the test site is 'noisy', some peaks will come and go, especially in the FM broadcast frequencies. Turn the UUT on. Remember that theanalyser should still be in averaging mode so any emissions from the UUT will take up to 30 seconds to show.

10. If any peaks appear, note the approximate frequencies so that they can be examined in detail at the next step. If the peaks drop when the UUT is switched off, it confirms that the peaks are genuinely from the UUT.

11. Examine the suspect peaks by setting the centre frequency to the suspect area and zooming down to 1MHz/div. Switch back to current trace and observe the effect of switching the UUT on/off. If the effect is obvious, the averaging can be switched off for an instantaneous result.

See section 6.4.12 on software operation for measurement of absolute levels and comparison with limit lines.

4.4 Conducted emissions

1. Connect the LISN to your mains supply.

NOTE: The mains supply must NOT be fitted with an RCB (earth leakage breaker) as the LISN will immediately cause this to trip. This is not a fault, all LISNs have this feature. If a non-RCB supply is not available, use a 240/240V isolation transformer of a current rating to match your product.

IMPORTANT: READ SAFETY INSTRUCTIONS IN LISN MANUAL

You are about to connect an exceptionally sensitive instrument (the analyser) with a full scale input of only 22mV to the mains!!! Follow the instructions listed below carefully. Avoid becoming too 'casual' when conducting these tests.

2. Switch the LISN controls to:

Input	Off
150KHz filter	IN
Attenuator	-20dB

3. Connect the UUT (unit under test) to the mains socket on the front of the LISN.

4. Connect a BNC lead between the LISN output socket and the input socket on the SA1020 pre-amplifier and a lead from the pre-amplifier output to the 4.5MHz range 50 ohm input on the analyser. (Located on the RHS). Leave the pre-amp switched off for the moment.

5. Set the analyser switches as follows:

Range	4.5MHz
Attenuators	IN
Scan Mode	500KHz/cm
Centre Freq.	2.50 MHz
Filter	OUT (always use this position unless using a scope)
B/width	Narrow
Sweep rate	Fully clockwise
Audio	Fully anti-clockwise

6. Start the software as described in the section above.

7. Check the system is running by temporarily adjusting the centre frequency controls on the analyser to approx. 2.00MHz. A peak should appear on the display near the left hand side. If this does not happen, check all connections and analyser switch settings.

8. If step 7 is OK, reset the centre frequency controls back to 2.50MHz

9. On the PC set the following: (working from the top down)

   From the Input menu, select LISN

   Click the following buttons:

Range	4.5	(some prompt screens will appear, OK each one)
B/width	Narrow	
Atten	In	
Pre-amp	Yes	
Input Impd.	50R	
LISN Source	Live	
150KHz filter	On	
LISN atten.	-20dB	

   There is a line of buttons marked Curr, Store, Diff, Limit along the bottom of the display. These control the traces on the screen. Switch Curr ON, all others OFF (greyed out)

10. Ensure the display is still Running.

11. Switch the Pre-amp ON.

12. The trace on the display should now be a line across just above the base line with just a little noise on it.

13. Switch your product OFF (if it was ON)

14. On the LISN, switch to L (live).

15. The trace should be essentially unaltered. If any significant peaks have appeared then they are due to radio signals picked up from the surroundings. If these are a problem, shorten the mains lead(s) to the product as much as possible, or use a screened room or the background subtraction technique. (See section. 6.4.12)

16. On the LISN, switch to OFF

17. Switch your product ON

18. On the LISN, switch to L (live).

19. The trace will now be displaying the spectrum of emissions from your product. **If** no peak is greater than half way up the screen, switch the input attenuator on the analyser OUT and change the corresponding item on the PC screen.

20. If the peaks are unstable (they probably are), select Peak from the Calculate menu.

21. Allow the system to run for some time until the display becomes stable.
22. If the trace is still only 1 or 2 divisions up the screen, switch the attenuator on the LISN to -10dB and change the corresponding item on the PC screen. Repeat 21.

    NOTE: Never switch the attenuator to 0dB position!!
23. Under the display, click on the 'Limit' button to switch the limit trace on.
24. From the Limits menu, choose the relevant limit line.
25. Compare your results with the limit.
26. Repeat step 18 onwards for Neutral, remembering to reset the Peak by selecting Off in the Calculate menu.
27. Repeat steps 16 onwards using Averaging instead of Peak to check the average against the limit lines.

See section 6.4.25 and 7.11 for use of the Quasi-peak mode.

If you need to look at the range above 5MHz up to 30MHz, use the 450MHz input on the analyser, select 450 range, 5Mhz scan mode, 25MHz centre frequency. Change the corresponding items on the PC screen.
The screen will now show 0 to 50MHz frequency range.

NOTES:
A. NEVER use the OUT position on the LISN (This is provided so that the LISN can be used as a means of injecting RF onto the mains.
B. ALWAYS select the OFF position on the LISN source selector switch before switching your product ON and OFF. This is just good discipline and avoids any possiblity of damaging the analyser or Pre amp with transients.
C. Only switch out enough attenuation to obtain usable readings. Do not attempt to obtain readings greater than absolutely necessary as this may lead to errors due to the impulsive nature of many mains borne emissions.
D. When making final measurements, check for the lack of compression by changing an attenuator setting and observing a corresponding change on the screen.

What I would do when measuring conducted emissions is as follows:

1. Set LISN filter ON
2. Select PEAK calculations
3. Switch LISN attenuator to 20dB
4. Switch analyser input attenuator IN
5. At the start, do not use the pre-amplifier between LISN and analyser
6. Set range to 4.5MHz, centre to 2.50MHz

In the following procedures, ***reduce attenuation*** means switching attenuation down by 10dB. This can be accomplished by a combination of analyser attenuator, LISN attenuator, use of pre-amplifier to give an end result which equals a 10 dB reduction in attenuation
Increase attenuation means increase attenuation by 10dB using the same facilities as listed above.

Switch the LISN source to L (L1)

1. Observe the signal on the screen.

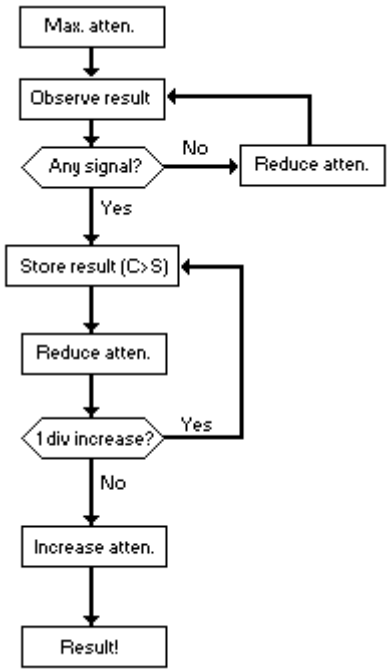
2. If no signal present, ***reduce attenuation*** and repeat 1
3. If signal present, use C>S button to store result.
4. ***Reduce attenuation***
5. Check the signal on the screen. If increase over stored result is approx 1 div then repeat 4.
6 If the increase is less than 1 division, ***increase attenuation*** back up by 10dB.
7. This is the best result. Make sure that the software switches match the settings on the LISN, analyser and pre-amplifier.

See attached flow diagram.

The procedure should be repeated for N (L2).

Then the average results can be taken <u>USING THE SAME ATTENUATOR SETTINGS</u>.

This procedure is essential if the EUT has pulsed emissions and should always be followed for conducted emissions.



5.0 THE HARDWARE

5.1 SA450B SPECTRUM ANALYSER

5.1.1 Overview

The SA450B is an all-analogue, conventional triple IF spectrum analyser covering the range 10KHz to 450MHz. It will function either when connected to a conventional 'scope (anything better than 1MHz bandwidth will do!) using the X-Y mode on the scope or a PC via the SA1030 interface and software. Both PC and scope may be used simultaneously if required.
Two sets of inputs are provided. The high frequency inputs at the LHS of the front panel cover the range 4MHz to 450MHz whilst the RHS inputs cover the range 10KHz to 4.5MHz. Although calibrated over these ranges, the top frequencies are in practice 500MHz and 5MHz respectively.
To aid display calibration and setting, the analyser generates a zero frequency marker which is output to both scope and PC. This is obvious when the analyser input is disconnected. A single peak at zero MHz will be displayed. This acts as a reference to check display settings.

5.1.2 Analyser Power

The analyser requires 240V or 110V 50/60 Hz ac mains supply. Note that all analysers are configured for 240V at the factory unless specifically ordered otherwise. If required to change the mains voltage setting the analyser must be returned to Laplace Instruments.
The power ON/OFF switch is located on the rear panel next to the mains input socket.

5.1.3 Analyser - Accuracy

The analyser is calibrated at the Scan Mode setting of 500KHz/cm for the high frequency range, and 50KHz/cm for the low frequency range. At higher Scan Mode settings the amplitudes of displayed peaks will be attenuated due to the finite response time of the I.F. filter and the high sweep rate. Thus when taking measurements, only use the high scan mode settings (50MHz/cm and 500KHz/cm) to identify the location of emission peaks (in frequency) then zoom into each peak in turn to measure the amplitude accurately.

5.1.4 Analyser - Controls

Note: The main controls are those on the front panel of the analyser. When using the analyser with a PC and the SA1030 software, the computer settings are set manually to duplicate the settings on the analyser. The computer does not control the analyser, nor can it 'read' the switch settings on the analyser.

5.1.5 Analyser frequency range

The SA450B is specified over the range 10Khz to 450MHz, although it will display the spectrum up to 500MHz. Sensitivity in the range 450-500MHz falls off by up to 10dB.
Most published EC standards require radiated emissions to be tested over the range 150KHz to 1GHz. The range above 500MHz has not been included in the 450B specification because the vast majority of electronic and electrical equipment is 'quiet' above a few 100MHz. In general, if the equipment under test is compliant up to 500MHz, it certainly will not have problems above 500MHz. However, if a product is specifically designed to operate at higher frequencies, or is capable of developing high power at MHz frequencies, it may be advisable to have these frequencies independently checked.
Note that two sets of inputs are used. The '450MHz' inputs cover the range 4MHz to 450MHz (500MHz).
The 4.5MHz inputs cover the range 10KHz to 4.5MHz

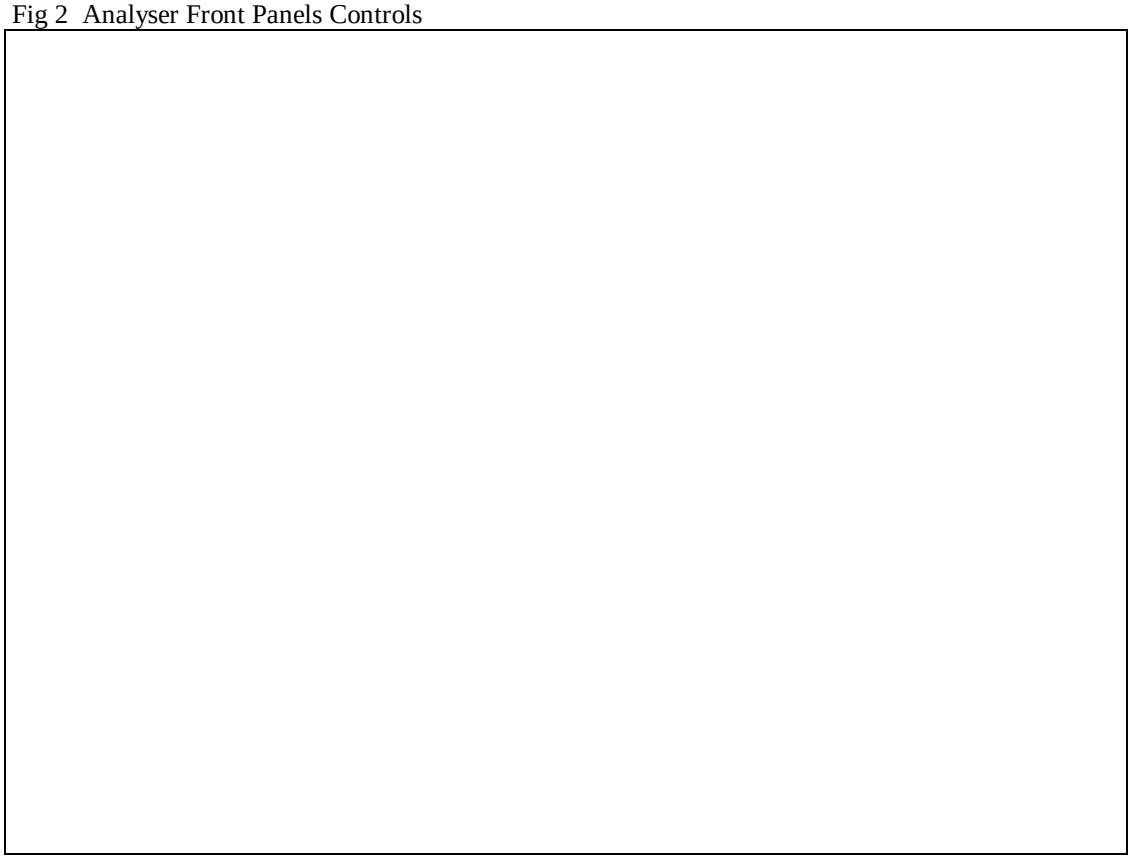
5.1.6 Analyser centre frequency

The display on the analyser front panel shows the frequency on the PC or scope screen corresponding to the centre graticule line. The coarse and fine controls enable rapid and accurate setting of this

centre frequency. If using a scope, the accuracy depends on accurate setting of the X position scope control (see section 5.2.5).

Two points to note:
1. If it is necessary to accurately measure the frequency of any one peak on the display, bring the peak to centre screen and read off from the digital display on the analyser front panel.
2. If you wish to 'zoom' in on any part of the spectrum, bring the required part to centre screen then use the SCAN control to expand the trace.

Fig 2 Analyser Front Panels Controls



5.1.7 Scan Modes

This control sets the frequency range of the horizontal axis. There are 10 divisions (cm) across a standard instrument screen, thus the full width of the screen is always 10 times the SCAN MODE setting.
Note the at small values of SCAN, the width of the I.F. filter will become apparent on any peaks. For instance, at 100KHz/cm scan mode and Wide B/width setting, all single peaks will be 1 division wide. For accurate peak amplitude measurement, always use Scan Mode settings below 5MHz/cm if Wide I.F. filter is selected, or 100KHz/cm if Narrow is selected.

5.1.8 Analyser bandwidth

The IF filter bandwidth in the SA450B analyser can be switched between 9KHz (Narrow) and 120KHz (Wide). These correspond to the filter bandwidths specified in the standards for emissions measurements.
9KHz is used for frequencies in the range 150KHz to 30MHz (conducted) and 120Khz is used for radiated emissions in the range 30MHz to 1GHz.
This switch must be set to correspond to the frequency range being measured in order to comply with the relevant standard.

5.1.9 Filter

The analyser output to the scope may contain significant high frequency 'noise'. This can be removed by using the FILTER switch IN.
This may attenuate the output to the PC serial interface so always switch the filter OUT when using a PC.

5.1.10 Oscilloscope sweep rate

Spectrum analysers are effectively swept frequency narrow bandpass filters. The sweep rate can be adjusted with this sweep control. Because the filters have a finite response time (inversely proportional to the filter bandwidth), slower sweep rates give more accurate results. However this has to be balanced against the readability of the display. For best amplitude accuracy, use either slow sweep rate or low scan mode. Both have the effect of giving the filter more time to respond.
NOTE: Turning this sweep rate too far anti-clockwise (slow) whilst using the SA1030 PC interface will result in failure of the PC to read the data.. An error message will appear on the PC screen. Simply increase the sweep rate, acknowledge the error and the system should start running normally again.

5.1.11 Baseline

This control can be used when displaying the output on a scope or PC. For the scope it shifts the whole trace vertically to allow adjustment of trace position for best viewing position.
Normally, keep this control fully anti-clockwise.

5.1.12 Audio demodulator

The audio output on the analyser can be used to identify broadcast and other background transmissions, to identify emissions sources (some have characteristic sounds) and to aid source location. In order to use the audio output, tune to the frequency of interest and turn the scan control to OFF. You now have a receiver tuned to that frequency. Slope demodulation is used, effective for both AM and FM signals.
When using near field probes to locate emission sources, a useful technique is to set the analyser centre frequency to exactly the frequency to be investigated, set the scan control to around 50KHz/div., (experiment with other settings too, as the optimum settings depend to some extent on the circumstances), turn up the audio demodulator volume and you now have a very sensitive sniffer probe with audio output, sensitive to only the frequency selected, and no need to watch the display!

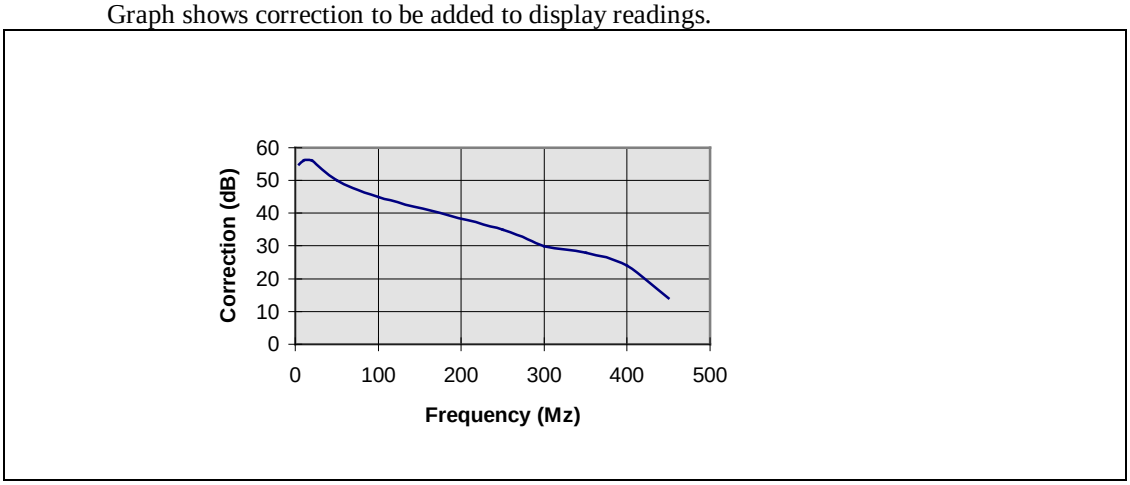
5.1.13 Range switch

Set to select the input frequency range currently in use. See next paragraph.
.

5.1.14 Inputs

2 groups of signal inputs are provided on the SA450B front panel.
At the left hand side are a pair covering the frequency range 4MHz to 450MHz. (High frequency)
At the right hand side are a similar pair covering the frequency range 10KHz to 4.5MHz. (Low frequency)
The Range switch should always be set to the range being used (4.5 or 450MHz). This both selects the appropriate signal input and switches the centre frequency display between X.XXMHz (low frequency) and XXXMHz (high frequency)
Each group has a 50ohm input and a Hi impedance input.
The analyser is calibrated for use with the 50ohm input and should be used with 50ohm coaxial cable and connectors. Always use this input unless using the analyser with a 'scope probe for checking/fault finding internal circuitry.
The Hi impedance input has an input impedance of nominally 50Kohm. On the low frequency range Hi impedance input the display will read 52dB low. ie if the display shows a peak at 20dBuV, the actual signal magnitude will be 72dBuV.
On the corresponding high frequency input the sensitivity varies with frequency as shown on fig 3.

Fig 3. Variation of sensitivity with frequency for the Hi impedance input
(High frequency range)
Graph shows correction to be added to display readings.



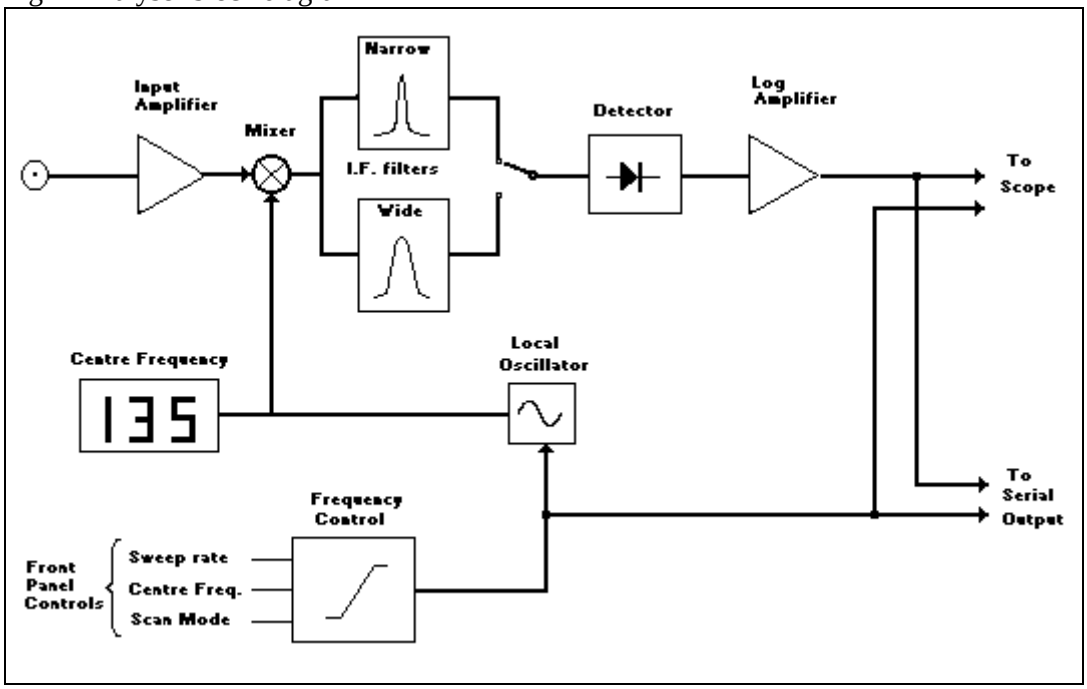
5.1.15 Input attenuator

Each input section is fitted with a switched 20dB attenuator. This helps in matching the input signal strength to the available linear dynamic range of the analyser.

5.2 ANALYSER OPERATION

The SA450B is an essentially conventional, analogue RF spectrum analyser.
Any signal connected to the input is first amplified and mxed with a local oscillator signal. The resultant difference signal is extracted by a low pass filter. This filter allows only a narrow range of frequencies to pass through. The width of this narrow range is set by the **B/width** switch to either 9KHz or 120KHz. The speed of the sweep is set by the **sweep rate** control. At its fastest this will sweep the selected range up to 8 times per second.
The range of frequencies over which this filter will sweep is set by the **Scan mode** and **centre frequency** controls.
The output from this filter represents the magnitude of the signal at the filter frequency. This is converted to a logarithmic magnitude and output to the PC interface and scope (vert) together with a signal proportional to filter frequency (horiz).

Fig 4 Analyser block diagram

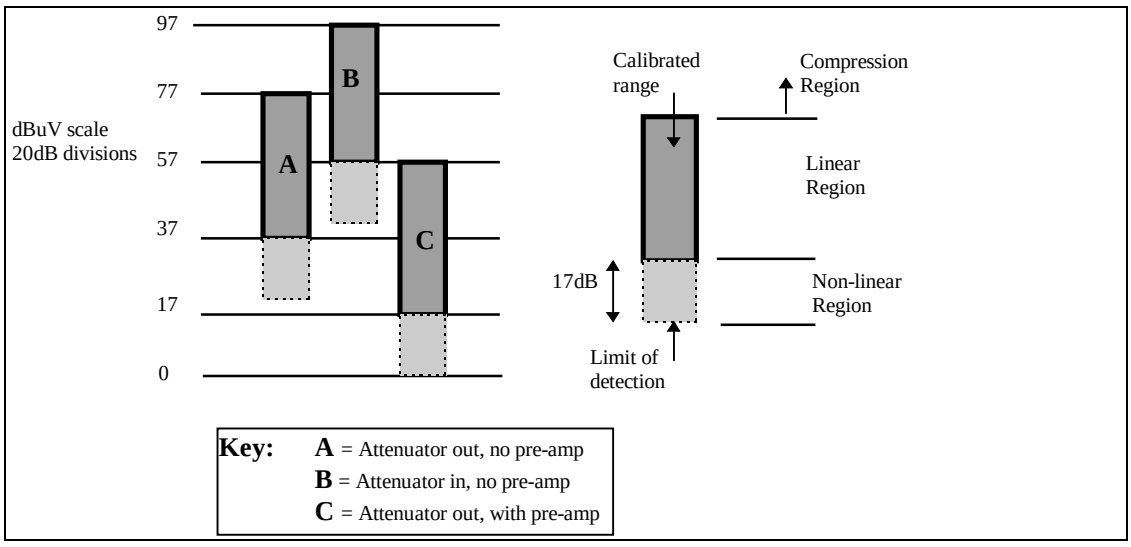


5.2.1 Analyser dynamic Range

The term Dynamic range for an analyser is a measure of the range of input signal levels which can be accurately displayed. At the low end, a signal below a certain minimum level will be lost in the noise floor. At the high end, above a certain level the input will start to saturate. The range between the low end limit and the high end limit is the dynamic range and is expressed in dB. The linear dynamic range of the SA450B is 42dB, a range of just over 100:1. In addition to this 'linear' range, there is an additional useful range which, although non-linear, increases the visible dynamic range to 55 - 60dB. See fig 6.

Spectrum analysers will give false readings if used outside the linear dynamic range. You have been warned! They are very sensitive instruments with inputs that respond to uV and must be handled with care. It is important to match the input signal level with the linear portion of the analyser's dynamic range. The input attenuator above each input connector on the analyser provides 20dB extra 'room' for high input signal levels and the SA1020 pre-amplifier provides 20dB extra for low input signal levels.

Fig 5 Analyser dynamic range



Please take note of the 3 precautions listed below.

Overload
Linearity
Distortion

5.2.2 Analyser overload

If directly connecting the analyser to signal sources such as a LISN or via 'scope probes to circuitry, be aware that the maximum signal level allowed is 220mV with the attenuator switched IN. *Signals larger than this may cause damage to the analyser. In particular, this restriction applies to transients so beware of switching 'glitches' etc*.

When using antennas or near field probes signal levels are very unlikely to exceed maximum levels. The analyser inputs are protected and will withstand levels of 2V or greater. The actual protection level depends on signal source impedance and duration. If using the LISN, always have the attenuator on the LISN switched to either -10dB or -20dB, never 0dB. Also, set the 150KHz filter IN unless specifically requiring to measure frequencies below 150KHz.

5.2.3 Analyser linearity

It is important to be aware that the magnitude of a signal on the display will differ from the true magnitude under certain conditions. Spectrum Analysers use a diode detector which has a linear range (in terms of output level vs signal strength) but at higher inputs the output starts to saturate. This effect is called compression because higher input levels are 'compressed' into a limited range.

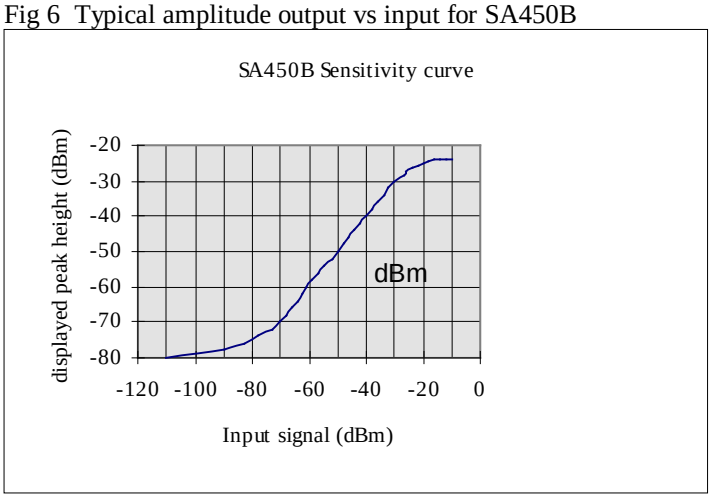
Similarly, an inverse compression appears at the bottom end of the range when the diode output is more sensitive than the linear range would imply.

As a guide, always adjust the input attenuator/pre-amplifier combination so that the highest peaks are at least 2 divs below the top of the screen. Much above this level the detector will start to go into compression.
The linear dynamic range of the analyser detector is 42dB (over 100:1). The pre-amplifier adds 18dB more sensitivity for low level signals and the attenuator adds 20dB to the top end of the range for large signals, giving a total of 80dB (10,000:1).

As a quick check, switch the attenuator IN/OUT and look for a corresponding 20dB change in the display. If the change is significantly less than 20dB, the analyser is going into compression.

The non-linearity at the low end of the range is a distinct advantage. At one division up from the baseline the display is linear, but below that division, the non-linearity is such that the true baseline (noise floor) is approximately equivalent to 2 divisions below .. Thus when using the pre-amplifier, the effective sensitivity of the analyser is approx. -107dB (or 0dBuV)

Fig 6 Typical amplitude output vs input for SA450B



5.2.4 Analyser distortion

If the detector is running in the non-linear region, cross-modulation and harmonic products will be generated within the analyser giving false readings. It is therefore important to ensure that the analyser is running well away from the compression region. Compression will start at around 1½ divs down from the top of the display. Therefore when beginning a test always check the display at full span width (i.e. 0-500MHz on 'high' frequency range or 0-5MHz on 'low' frequency range) and check that no peaks are at or above this level. If they are, switch in the attenuator and/or take the pre-amplifier out of circuit.
Note that the full frequency band must be checked. It is no use just checking say 0 - 100MHz on the basis that this is the only range you intend to use today. A strong signal at 300MHz could be causing the detector to go into compression and affecting the 0 - 100MHz range.

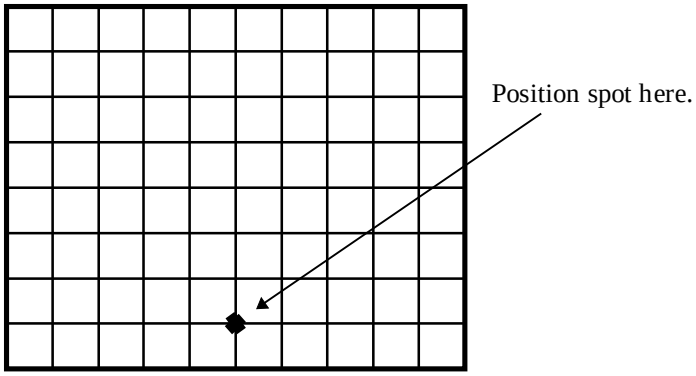
5.2.5 Operation with Oscilloscope

The SA450B may be used with an oscilloscope rather than or as well as a PC. One advantage of the 'scope is that the display will update approx. 10 times faster producing a 'real time' response. The disadvantage is that non of the software features are available on the 'scope.
Oscilloscope requirements
Any conventional scope that can operate in X/Y mode with a bandwidth 1MHz or greater.

The settings are: Inputs DC coupled
Y input 50mV/div
X input 1V/div

Connection and initialisation
Set the ‘scope settings as above, with the timebase set to X/Y mode
With the inputs set to GND, adjust the centre spot to centre screen and 1 div up from the baseline

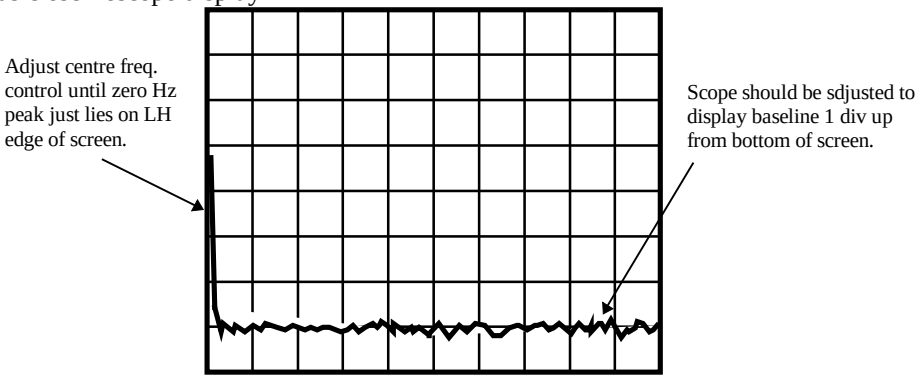
Fig. 7 Scope initial settings



Switch the scope inputs back to DC coupling.
Connect the ‘scope outputs from the SA450B to the X and Y inputs on the ‘scope. You should get a trace as shown in fig.8 If the trace shows as a vertical line, you have probably reversed the inputs!
Set the analyser front panel controls as follows:

Input attenuator:	Out
Scan mode	50MHz/cm
Range switch	450MHz
Filter switch	in
Bandwidth	wide
Baseline	Fully anti-clockwise
Sweep rate	approx. mid setting
Audio gain	Min.
Centre frequency	250MHz

Fig.8 Basic oscilloscope display

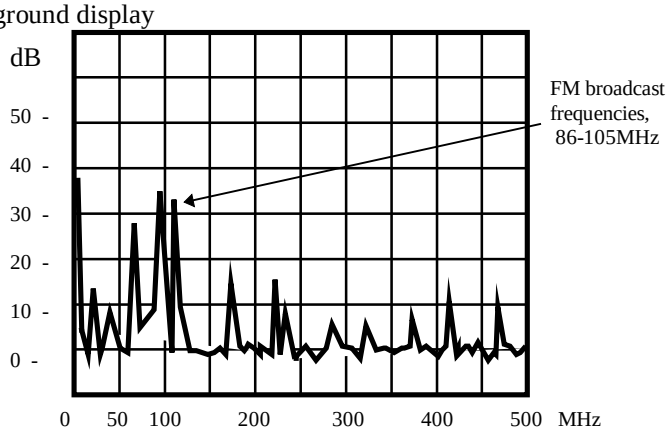

Adjust centre freq. control until zero Hz peak just lies on LH edge of screen.
Scope should be sdjusted to display baseline 1 div up from bottom of screen.

Adjust ‘scope X shift and gain to position the trace so that it just extends over the 10 divisions of the graticule.

The horizontal scaling will be 50MHz/cm with zero at the LH edge, 250MHz centre screen and 500MHz at the RH edge. Vertical scaling is 10dB/div.
NOTE: Oscilloscopes tend to drift, especially within the first 30 minutes of switching on a they warm up. In particular the horizontal shift will need repeated checking by switching the horizontal input on the scope to GND and readjusting (if necessary) the spot to centre screen.

Connect an input to the analyser 450MHz input. If using an antenna, connect to the 50ohm input and switch the input attenuator out. You will probably also need to use the SA1020 pre-amplifier.

Fig 9 Typical background display



Signals can be examined in detail by bringing the peak to be checked to centre screen by using the centre frequency controls on the analyser. Once a peak is centred, the scan mode control can be used to 'zoom' into the peak, fine tuning the centre frequency controls as required. The centre frequency display will indicate the precise frequency of the peak and the amplitude can be accurately measured. To listen to the signal, turn up the audio volume control. The internal loudspeaker in the analyser will output any audio modulation of the signal. The sweep rate of the analyser will be superimposed on the signal. This can be switched off by switching the scan mode switch to OFF.

See section 5.1 for further details of analyser control usage.

5.3 SA1020 Pre-amplifier

5.3.1 Description

The SA1020 is a small self contained amplifier intended to provide in-line signal amplification for low level RF signals such as output by radio or EMC antenna and near field probes, and to provide an output suitable for RF spectrum analysers, oscilloscopes or other measurement or recording instruments.
In order to maintain high signal to noise ratio and to offer maximum operational convenience, the unit is internally battery powered with a standard PP3 battery. This may be either primary cell type, or rechargeable (eg NiCad).

5.3.2 Battery installation

Suitable batteries are any PP3 type such as alkaline or rechargeable types such as NiCad.
To fit the battery, push off the moulded battery cover as indicated on the rear of the SA1020. This will reveal the battery compartment and the battery connector. Ensure that the ON/OFF switch is set to OFF before connecting the battery to the connector and that the connector is correct orientation before pushing the contacts home. Check that the contacts are both fully engaged before inserting the battery in the battery compartment. Clip the battery cover back in place.

Make sure that the battery is not discharged by checking the battery voltage with a meter before fitting the battery cover. With the battery connected to the SA1020, and the unit switched ON, the battery voltage should not be less than 8V

With a fully charged battery, the amplifier should run for the following periods:

Battery type	Capacity	Duration
NiCad	110mAH	5 hour
Alkaline	200mAH	10 hour
Zinc-Air	1000mAH	50 hour

Avoid using 'cheap' batteries. They are a false economy!

5.3.3 Operation

Important notes

1. The amplifier is intended to be used with low level signals, of uV amplitude rather than Volts amplitude. The input is therefore very sensitive and , although protected, may be damaged if input voltages exceed the specified values. When used with the SA450B analyser and to ensure linear operation, input signal amplitude should not exceed 22mV rms in the frequency range above 5KHz. For signals with frequencies below 5KHz the internal ac coupling permits higher input voltages. The slope of this characteristic is 3dB/octave which gives a max. voltage input of 2.2V at 50Hz.
2. If the input is subject to overload voltages, a diode clamping network will protect the amplifier. However, this network has limited current capacity so that the degree of protection and the overload voltage which the unit will withstand depends on the source impedance of the signal.
3. During use, monitor the condition of the battery. Low battery condition is manifested by a reduction in output signal. This occurs quite abruptly if using NiCad cells.
4. When not in use, switch the amplifier off to preserve battery life. If the unit is not to be used for any significant period, disconnect the battery. This avoids batteries being drained inadvertently.
5. Two SA1020 amplifiers may be cascaded in series. For optimum results, fit a 3dB attenuator between the two amplifiers and after the second. This gives an overall gain of nominally 32 dB.
6. Dispose of used batteries properly.

5.4 RF100 Near Field Probe set

Near field probes can be used for the location of emission sources and for monitoring the effectiveness of design changes, circuit improvements and screening.
They should not be used to assess emission levels as required by the legislation because this requires measurement of the far field.
Sources of radiated emissions may be current or voltage in nature. Low impedance sources will be current sources and generate magnetic fields (H field). High impedance sources generate electric fields (E field). Most electronic circuits exhibit H field radiation because the sources are allied to current flow.
The H field loop and the E field stub antenna are included in the near field probe set so that both types of sources can be traced. The output signal level of both are very dependant on proximity to the source. Generally, more than a few centimetres from the source and the output from the probes will drop to virtually zero. This makes the probes ideal for use in noisy ‘laboratory’ environments and for accurate pin-pointing of sources.
Some sources can be related to lengths of cable or internal wiring. Often the user will find nodes and anti-nodes (standing waves) along the length of these conductors, the E and H fields being in antiphase. Therefore when checking conductors, it is important to check along the length of the conductor to ensure detection of a node.
Note that the level of signal picked up by the near field probe does not give any indication of the field strength in the far field. The probes respond to source intensity and do not take into account how well that source is coupled to the environment.

5.5.2 RF300 Large Loop Antenna

This antenna complies with EN55015 and should be used when testing luminaires.
See separate user guide supplied with the RF300 for details
Note that the antenna factor for the RF300 is included with the EMCEngineer software.

5.5.3 RF400 RF Absorbing Clamp

This clamp is required for testing to EN55014.
See separate user guide supplied with the RF400 for details.

5.5.5 Antenna Factor

The sensitivity of any antenna will vary with frequency. i.e. it will be more sensitive at some frequencies and less sensitive at others. A plot of sensitivity vs frequency is called the Antenna Factor. The SA1030 Windows software has the antenna factor for the RF200 broadband antenna ready installed. Selecting this item in the INPUT menu automatically applies the appropriate conversion to read out in absolute field strength.
WARNING: Although the conversion is valid, the field strength measured by the antenna is subject to your test site conditions and configuration and may be subject to gross errors. Reception of emissions radiated from the UUT depend on the test conditions, the test site, reflections, ground plane, background radiation, UUT to antenna distance etc..etc.. Be very wary about relating field strengths to limit lines unless you have some known test results to act as a reference. Se section 7.16 for details of the ERS emissions calibrator.

RF200 Antenna Factor tabular data

Freq(MHz)	A.F. (dB/m)	Freq(MHz)	A.F. (dB/m)	Freq(MHz)	A.F. (dB/m)
30	0	220	-3	460	4
40	-1	240	-2	480	5
50	-2	260	-4	500	5
60	-3	280	-5	550	6
70	-5	300	-3	600	7
80	-7	320	-2	650	9
100	-9	340	-1	700	10
120	-9	360	0	750	11
140	-8	380	1	800	12
160	-7	400	2	850	13
180	-6	420	3	900	13.5
200	-5	440	3	950	14
				1000	14.5

Fig 13(a) RF200 Antenna factor, linear frequency scaling.

Note. Antenna factor includes SA1020 Pre-amplifier and 5 metres co-ax cable.

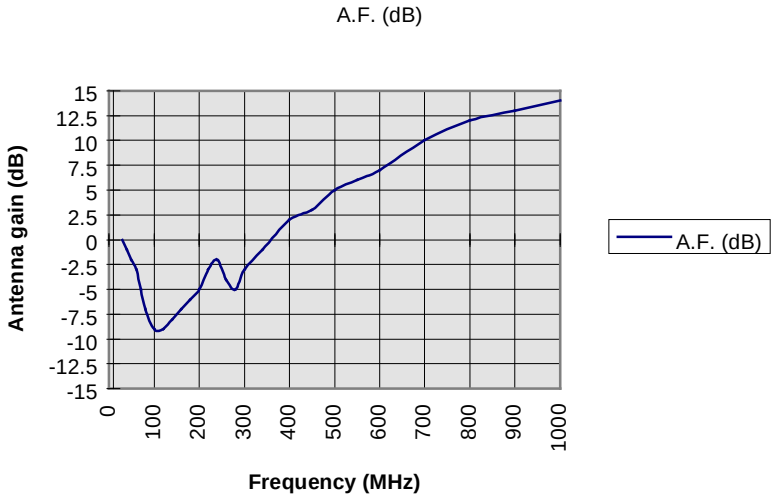
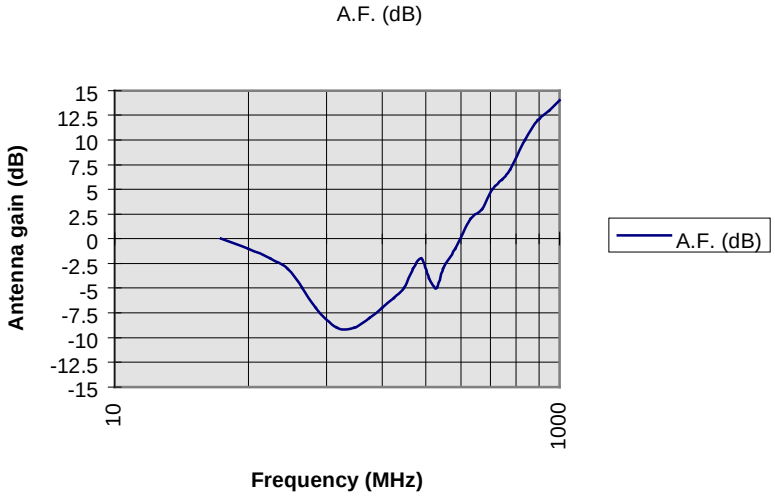


Fig 13(b) RF200 Antenna Factor, Log frequency scaling

Note. Antenna factor includes SA1020 Pre-amplifier and 5 metres co-ax cable.



5.6 LISN1600

LISN stands for Line Impedance Stabilisation Network.

The LISN provides the 'transducer' for measurement of RF conducted back down the mains from the Unit Under Test (UUT).

It is located in the mains feed to the UUT and primarily provides a known calibrated load impedance at RF frequencies for RF emitted by the UUT back down the mains lead.

Secondary functions included with the Laplace LISN1600 are:

(i) Attenuation for low frequency signals i.e. the 50Hz mains component and its harmonics as these would overload the input to any spectrum analyser unless they were substantially reduced.

(ii) Filtering the incoming mains before it reaches the measurement point so that RF already present on the mains supply will not affect the readings.

(iii) Providing a switch to select live or neutral so that both can be tested (as required by the standards)

(iv) Additional attenuation of signals below 150KHz. Most standards have a lower frequency cut-off point of 150KHz, therefore by filtering out signals with frequencies below this point we can maximise the performance of the analyser.

(v) Switchable signal attenuation and voltage limiting to protect the input of the spectrum analyser.

5.6.1 LISN - Connections

NOTE: Before using LISN, read safety instructions in LISN manual

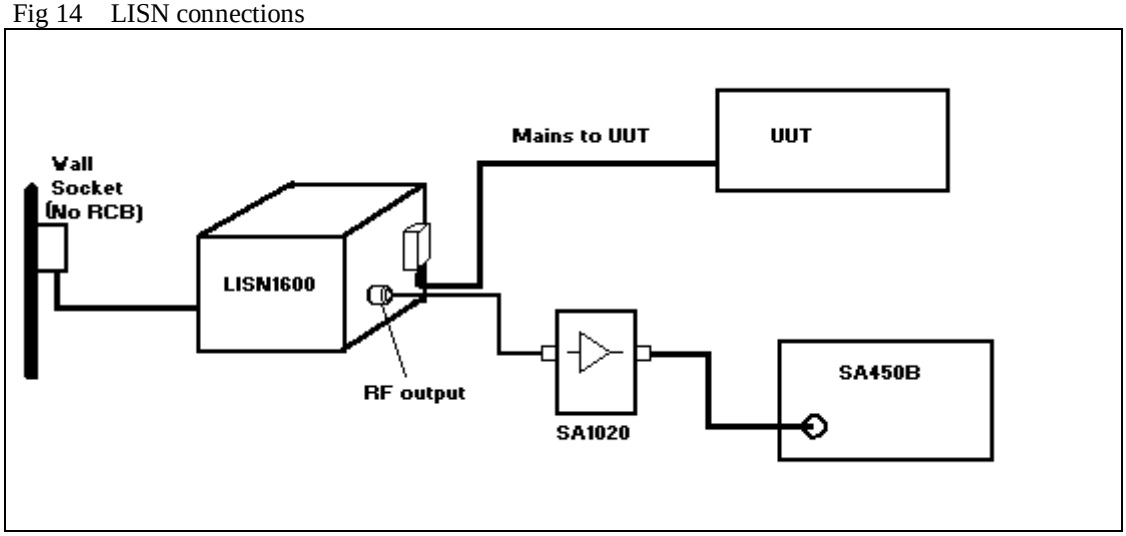
Mains ... The mains lead from the UUT is plugged into the mains socket on the front of the LISN. The mains lead from the rear of the LISN is connected to a mains supply. Note that there is no mains ON/OFF switch on the LISN so that the front panel socket is always live when the LISN is connected to a live supply.

LISNs will always trip RCB (earth leakage) breakers. If no supply is available without an RCB, use a isolation transformer with an appropriate rating for the UUT.

Signal...Then RF signal is taken off the front panel BNC connector. This should be connected to the analyser input via a coaxial cable. Note: ALWAYS leave the LISN attenuator switch in the -20dB position to ensure maximum protection to the analyser against transients and overload conditions. If required, the -10dB attenuator position can be used, **but never use the 0dB position**.

If greater sensitivity is required use the SA1020 preamplifier in series between the LISN and analyser to obtain a 20dB gain.

Fig 14 LISN connections



5.6.2 LISN Calibration

The LISN1600 provides a 1:1 scaling between mains connection to the UUT and output BNC for frequencies from 10KHz to 30MHz. In other words, a 50dBuV signal from the UUT will ‘arrive’ at the output BNC as a 50dBuV signal if the attenuator was set to 0dB.
Proper use of the settings in the LISN control box on the EMCE screen will ensure that the readings will be accurate whatever the LISN attenuator is switched to.

5.6.3 LISN Attenuator

The recommended settings for the LISN are to use the 20dB attenuator position, and switch the 150KHz filter in.
The attenuator provides output protection on the signal to reduce the chance of overloading the sensitive input to the analyser. If the output is taken via a SA1020 pre-amplifier the 20dB attenuation is cancelled giving the best of both worlds, with the protection of the attenuator and yet retaining the full sensitivity of the LISN.

If greater sensitivity is required, use the -10dB attenuator switch position, but never the 0dB switch position as this switches the limiter circuit out, thus depriving the analyser input of protection against transients.

Full operating instructions for the LISN are given in the separate booklet provided with the LISN.

6.0 SA1030 EMCE System

The EMCE system comprises the EMCE software, version 2.77, and serial interface to an SA450B spectrum analyser.

6.1 Compatibility

The EMCE software will run on any PC compatible with Windows, running Windows 3.1 or higher or Windows 95 and having a VGA monitor as a minimum.
The interface will connect to the standard serial port, either COM1 or COM2. The appropriate port must be selected in the Port menu before acquiring data.
Certain PCs may experience conflicts between the mouse and the serial port. See section 6.3.2 for more details.

6.2 Installation

The software is provided on a 3½" disk in compressed format.
To install this software on your PC:
1. Load the disk into drive a:

2. Type "a:\install" {enter}. (Or run install.bat from Windows file manager)

   This will place the appropriate files in your Windows system directory and create a new directory "c:\emc_eng"

   If you wish, you can now run the software by entering Windows and using the File Manager. Double click on the File Manager icon, find the emc_eng directory and double click on the emcb2.exe item.

3. If you wish to use an icon to access the program, start Windows and select a program group in which you wish the icon to appear (the selected program group will have a highlighted title)

4. From the tool bar across the top of the screen, select File

5. Select New....

6. Place a bullet next to "Program item" & click OK

7. In the box labelled "Command line" type:

   c:\emc_eng\emcb2.exe"

   Click OK

8. The EMCE icon will now be installed, although you may have to adjust its position to make it visible in the program group window.

6.2.1 Installing an upgrade

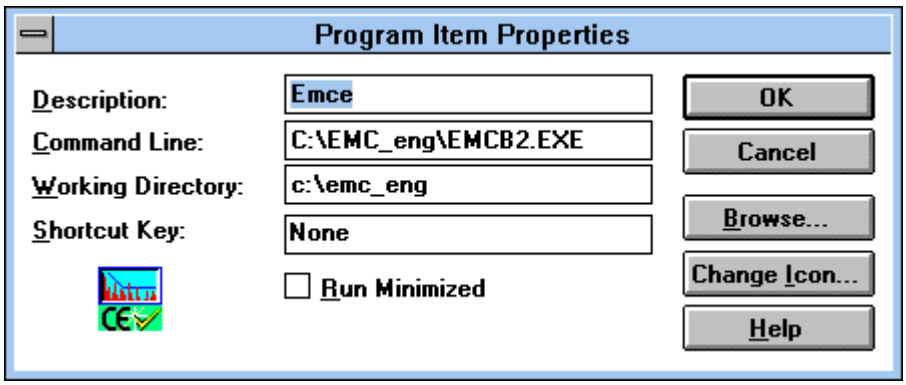
This section is only valid if upgrading an existing version of EMCE software with a later release.

Use Install on the new supplied disk.

This places the program in directory EMC_ENG

Any contents of an existing EMC_ENG directory are transferred to a sub-directory EMC_$OLD

Any earlier version using a different directory, change the icon attributes to associate it with the new software.
To do this, highlight the icon and press ALT + Enter.
Change the properties screen as shown below.



6.3 Controls

Two sets of controls are used in the EMCE system. The analyser is controlled by the physical switches and knobs on its front panel. These are the 'real' controls. The second set of controls are set on the computer screen and (in the main) are driven by the mouse. These are set manually to duplicate the analyser controls. The software cannot read the settings of the SA450B controls electronically, hence the user must accurately enter the settings manually in order for the screen to display the correct information and scale the traces properly. Therefore whenever taking 'formal' readings, always remember to check that the control settings on the screen match those on the analyser.

The controls which must be set on the screen in order for the display to read accurately are:

Scan (MHz/div.)
Centre Frequency
Frequency Range (450/4.5 MHz)
Input Attenuator
Input Impedance (50R/High Imped.)
LISN attenuator settings (if used)
Input menu (signal source)

6.3.1 Mouse/key operation

The software would normally be driven with the mouse. However, if a mouse is not available (perhaps due to conflict between mouse port and SA1030 serial interface, the software can be driven from the keyboard.

Each 'active' button is highlighted. This highlight can be moved from group to group with the TAB key. Within each group the highlight can be moved using the cursor keys and a selection made by pressing the space key. To select a main menu press ALT+(the letter underlined in the menu title). Other groups or choices can be selected by just pressing the letter only. Thus "2" will select 20dB attenuation in the LISN box if LISN is active.

6.3.2 Mouse interaction

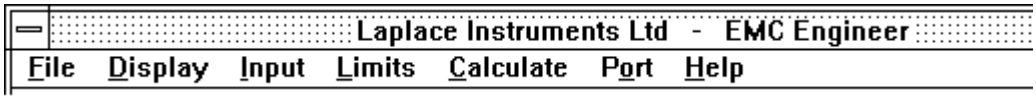
On some PCs, the mouse and the serial port interrupts clash. This is a function of the hardware and there is no software cure other than to disable the mouse whilst the port is receiving data. The symptoms of this problem are an I/O buffer error or Short Frame error message appearing on the screen when the mouse is moved.

There are two solutions:

1. Do not move the mouse whilst in 'Run' mode. If the mouse is left positioned over the Run/Stop button, clicking the mouse will turn the acquisition of data on and off. Always revert to Stop mode before using the mouse to make any other selections.
2. Under the Port menu, one of the options is a 'Port has priority' switch. By selecting this on, the mouse is disabled during data transfer and the problem is averted.

NOTE: The default on the software is to have the 'Port has priority' disabled.

6.4 Main menus



6.4.1 File...New

Clears all input data from the current, background and difference traces. Resets the Averaging and Peak arrays and sets the LIMIT trace to OFF.
Resets all the setup conditions to default conditions.

6.4.2 File...Open

Loads data from a previously saved file.
Options allow loading of only selected traces (Current, Stored or difference) so that results of different tests can be compared. The screen will retain any existing trace that is not loaded during the Open command. Thus if you need to compare a current trace with a previously saved trace, first copy the current trace to Stored using the C>S button then load the previous file with Stored and difference deselected. The result will be a current trace showing the 'old' data and the stored trace showing today's data.
Note that the two sets of data must be acquired with the same set-up conditions.
Other options allow selection of directory and drive.

6.4.3 File...Save as

Saves the results currently on screen to disk.
The data saved includes:
Date and time

- Set-up conditions
- Current trace data
- Background trace data
- Difference trace data
- Comments

The file format is simple ASCII with a header for the set-up data and 3 columns of trace data.
The default extension is .EMC
The options include entry of file name, selection of directory and disk drive.
File...Save
As above, but assumes same file name as previously saved file. Will display message on screen warning of file overwrite before proceding.

6.4.4 File Format

All files written to disk are in ASCII format
The delimiters are: End of line = CR,LF
Between data fields = tab

The data is organised as follows:

Line number	Number of fields	Field number	Details
1	1		Version of software which wrote the file
2	1		File type, set to “data”
3	1		User entered narrative
4	1		XL - Limit name
5	1		XP - Port
6	1		XT - Time
7	1		XA - Antenna factor name
8	1		Xl - Dipole length (note: lower case el)
9	1		Xc - average count
10	1		Xi - Input index
11	1		Xd - Antenna - product distance
12	1		Xa - Antenna factor index
13	1		XF - Pulse repetition rate
14	1		Xp - Peak (Boolean, T or F)
15	1		Xq - Q-peak (Boolean, T or F)
16	1		XX - Linear freq. Axis (Boolean, T or F)
17	1		XY - Log freq. Axis (Boolean, T or F)
18	1		Xz - High impedance (Boolean, T or F)
19	1		Xg - Pre-amp (Boolean, T or F)
20	1		XN - LISN (Boolean, T or F)
21	1		X+ - LISN source +ve (Boolean, T or F)
22	1		Xf - LISN filter (Boolean, T or F)
23	1		X1 - LISN atten 10dB (Boolean, T or F)
24	1		X2 - LISN atten 20dB (Boolean, T or F)
25	1		Xv - visible traces (CBDL = current background diff limit)
26	6	1	Scan mode settings, 0=off, 1=1KHz.....11=50MHz
		2	Centre frequency (in MHz)
		3	Attenuator, 0=in, 1=out
		4	Filter, 0=in, 1=out
		5	Bandwidth, 0=wide, 1=narrow
		6	Range, 0=450MHz, 1=4.5MHz
27	7	1	Input trace, 0=off, 1=on
		2	Stored trace, 0=off, 1=on
		3	Difference trace, 0=disable, 1=enable
		4	Input trace, 0=not stored, 1=stored
		5	Stored trace, 0=not stored, 1=stored
		6	Scan mode, 0=single shot, 1=free run
		7	Average setting, 0=1 av, 1=2 av, 2=4 av, 3=8 av, 4=16 av, 5=pk
28 to 628	3	1	Input trace, amplitude in pixels
		2	Stored trace, amplitude in pixels
		3	Difference trace, amplitude in pixels

Rows 6 to 606 contain the data points for each trace. The first 540 points are plotted across the screen, 54 points per division.
Vertically there are 40 data points per 10dB division and zero = baseline
If importing the data into a spreadsheet, apply scaling factors using the data above to obtain correct values.

Typical file

2.68
data
vertical at 3m
XLEN55022 Class A radiated
XPCOM1:
XT29-Dec-1995 15:04
XALISN
Xl2
Xc8
Xi3
Xd30
Xa0
XF100
XpF
XqF
XXT
XYF
XNT
X+T
XfT
X1T
X2F
XvC-DL

3	2.200000		0	1	1	1
1	0	1	0	0	0	1
0	0	0				
0	0	0				
71	90	0				
115	108	55				
97	80	64				
122	106	87				
96	83	55				
106	100	42				
..	...	..				
..	...	..				
..	...	..				
..	...	..				
4	8	0				
20	20	0				
20	20	0				
16	20	0				
0	0	0				

6.4.5 Printer setup

Standard Windows printer setup selection screen which allows control of printer type, format (landscape or portrait), paper size, printer port etc...

6.4.6 Print

Prints a hard copy version of the current screen data.

6.4.7 Exit

Exits from the EMCE program. All data currently not saved to disk will be lost.

6.4.8 Display menu

The Display menu enables the user to control which traces are visible.
See also section 6.4.9 for a shortcut method of trace control.
Up to 4 traces can be displayed on the screen at any one time. These are:
Current. This is the current input signal
Store. This is a trace copied from the current trace. Normally used for background nulling.
Difference. This is a plot of Current - Background trace.
Limit. Plots the selected limit line.

Reset will reset the whole system back to default conditions.

6.4.9 Instant display toggle keys

The buttons at the lower edge of the graphic display window are provided to allow easy ON/OFF switching of the 4 traces. Note that the colour dot indicates the colour of the respective trace.

6.4.10 Display...Current

The Current trace (black) is the spectrum of the current signal input to the analyser. All calculated functions (averaging, peak and quasi-peak) are applied to this trace. This trace may be copied to the stored trace by using the C>S button.
Selection of this item on the Display menu toggles the Current trace ON/OFF.
Toggling the trace OFF will not cause loss of data.

6.4.11 Display...Stored

The Stored trace (red) is used for recording the background emission level or for comparing two traces. Data can be transferred to this Background trace from the Current trace (using the C>S button) or loaded from disk from a previously recorded file.
This trace is used to compute the Difference trace.
Selection of the Display...Stored menu item toggles this trace ON/OFF.
Toggling the trace OFF will not cause loss of data.

6.4.12 Display...Difference

The Difference trace (magenta) is the computed difference between the Current trace and the Stored trace.
i.e. Current minus Stored.
The main purpose of this trace is to enable measurement of radiation from a product in the presence of background radiation, as will be the case on any open field test site.
When using this trace for background subtraction, see section 7.8, radiated emissions testing.
Note that the difference is calculated for each frequency point by subtraction of the other two traces at the corresponding frequency point. Because the data is in logarithmic scaling, each value is converted to linear units first, then subtracted, then converted back to log scaling.
If the current trace value is less than the stored trace value, the resultant defaults to the bottom edge of the graphic display screen.
Logarithmic scaling has the effect of making small differences between current and stored traces appear as relatively large peaks on the difference trace. In order to work with a relatively quiet difference trace, the use of averaging or peak detection is essential.
Selection of the Display...Difference menu item toggles this trace ON/OFF.
Toggling the trace OFF will not cause loss of data.

6.4.13 Display - limit

The Limit trace (yellow) will display the currently selected limit values on the screen.
The limit line is selected under the Limits menu.
Selection of the Display...Limit menu item toggles this trace ON/OFF.
Toggling the trace OFF will not cause loss of data.
The limit line will be scaled and adjusted to suit the current display settings.

6.4.14 Display...Reset

Clears all input data from the current, stored and difference traces. Resets the Averaging and Peak arrays and sets the LIMIT trace to OFF.
Returns the set-up conditions to the default settings.

6.4.15 Limits

Limit lines, as specified by certain EN standards, can be displayed on screen. The Limits menu allows selection of the appropriate limit.
The limit line will be scaled and adjusted to suit the current display settings.

WARNING
The limits will be at the correct level according to the current display settings. (i.e. scan width, centre frequency, attenuation, pre-amplifier, LISN settings etc...) Any errors in the set-up conditions will cause corresponding errors in limit line comparisons with the signal traces.
In particular:

Limit lines must not be used with near field probes.
When used with a far field antenna, large loop antenna or absorbing clamp, compensation for antenna factor must be made.
Allowances for test set-up and test site calibration must be made.

The analyser must be used as specified in section 5.1.3 to achieve accurate magnitude readings. In particular note that low scan mode settings must be used to produce an accurate peak height.

6.4.16 Input Menu

The Input menu allows the user to specify the source of the signal to be input to the analyser. The software will automatically adjust the scaling of the display to match the source. For instance, if the RF200 is selected, the antenna factor for the RF200 antenna will be implemented and the display will read directly in dBuV/m field strength.
If a 'straight' readout of the signal received at the front panel BNC is required, use the Direct item.

6.4.17 Input - RF100

This item displays and stores the data from the analyser without processing or applying any antenna factor compensation. The RF100 near field probe set cannot be used for absolute field strength measurements, it can only be used for comparative and qualitative work. The 50ohm inputs should be used and, for most work, use the SA1020 pre-amplifier. However for strong sources the SA1020 may not be necessary.

6.4.18 Input...RF200

The RF200 broadband antenna from Laplace is a 30MHz to 1GHz antenna with a known antenna factor. This antenna factor is loaded with this EMCE software and when this item is selected the antenna factor is automatically used to display field strength as measured by the antenna. Although these readings will be correct (within the ±6dB error budget of antenna + analyser) for field strength as received by the antenna, test site conditions have to be very carefully controlled if these readings are to have any meaning. To improve the accuracy and integrity of readings the ERS (Emissions Calibration Source) can be used.
NOTE When using the RF200 antenna, it must be assembled as specified in the instructions in section 5.5.1 with the SA1020 pre-amp installed at the head of the antenna**.**

Antenna distance

This is the distance from the UUT and the antenna. It is measured in metres from the outer surface of the UUT and the effective centre of the antenna (the centre mounting boss).
This parameter must be accurately entered into the EMCE software when selecting antenna type if comparison with limits is to be achieved.
The field strength from any point source is inversely proportional to the square of the distance from the source and the limit levels are specified by the standards at a specified distance from the UUT (usually 10m or 30m). If measurements are undertaken in the presence of background radiation, it is normal practice to considerably reduce the antenna distance (i.e. to less than 10 or 30m) so that the radiation from the UUT is increased relative to the background. Having reduced the antenna distance, the limit levels must be adjusted (increased) to take into account this reduced distance. The

EMCE software will automatically calculate the new levels to conform with the entered antenna distance. The allowable range is 1 to 30 metres. **The Standards suggest that a minimum distance of 3m should be used.**

Input... RF300 Large loop antenna

This item corrects the readings over the range 10KHz to 30MHz for use with the RF300 antenna.

Input... RF400 RF absorbing clamp

Select this item if using the RF400. The antenna factor compensation for the RF400 will be automatically applied. Note the requirement to search along any cable for maxima closest to the EUT.

6.4.19 Input...RF500

The RF500 tuned dipole can be tuned to frequencies between 80MHz and 300Mhz by adjusting the element lengths to ¼wavelength. See Dipole section 5.5.4. The display will show the approximate field strength scaling for the frequencies close to the tuned frequency but will be in error at other frequencies.

6.4.20 Input...LISN

Use this item if measuring conducted emissions with the LISN1600. The software will activate the LISN control box on the screen allowing entry of the LISN settings.
These are source (Live or Neutral), 150KHz HP filter (in/out) and attenuator setting (0, -10, -20dB). The software will use the attenuator settings to set the scaling of the screen.
NOTE: Spectrum analyser inputs are very sensitive. Great care must be taken not to overload the input, especially when connected to the LISN. It is normal RF analyser practice to disconnect the analyser input whilst switching/connecting the UUT to the mains. This is to avoid potentially damaging high frequency transients being input to the analyser. The Laplace LISN1600 has a built-in transient limiter to protect the analyser. If using any other LISN, fit a voltage limiter in the signal lead.
When first beginning a test with the LISN, ALWAYS start with the LISN attenuator set to -20dB, 150KHz filter switched IN and the SA450B attenuator switched IN. This gives an overall attenuation factor of 60dB and the display vertical scale should show 70dBuV to 130dBuV. Check the full span of the analyser to ensure that no peaks are greater than 100dBuV. Only if this is true, switch out the SA450B attenuator and check the full span again. If no peaks are greater than 80dBuV, connect the SA1020 preamplifier in circuit to give an extra 18dB gain. Only if no peaks are now greater than 60dBuV, switch down the LISN attenuator. The whole point to this exercise is to ensure that no peaks should approach 75% of full scale.

6.4.21 Input...direct

This item should be used if connecting directly to any signal source or simply wishing to ensure that the software does not process the incoming data in any way, other than scale adjustment for pre-amplifier and input attenuator. Calculate functions are treated separately.

6.4.22 Input...others

This section is provided so that 3rd party antennas can be used with this system. It allows entry of up to 4 antenna factor compensation data. This may be used for the purpose of using other antennas or for correction of an antenna + test site combination, using a calibrator as a reference. (See section 7.16). The data is entered as a series of nodes specifying sensitivity vs frequency. The software will compute straight line or logarithmic interpolation between the entered nodes.
Several A.F. data sets may be entered and each filed under a user specified name. All the antenna factor data is stored in a separate file called ‘antenna.ini’.
When an antenna factor data set is invoked, the software will display field strength on the vertical axis and automatically compensate the incoming spectrum.
This antenna.ini is for use with versions 2.53 upwards. Any previous user-defined antenna factors should be edited and upgraded to conform to this new layout if they are to be used with antenna-product distance aspects of the software.

Antenna.ini file.
This will be found in the emc_eng directory and can be edited with any standard word processor, including Windows Write. Note that if using Write, do not allow Write to convert the file to Write format.
The first entries in here are the stock antennae - should be left as they are. Add user defined ones wherever you want, but ensure they follow the rules:

(1) MUST start with ANTENNA

(2) the word ANTENNA must be followed by an unique name. (No spaces allowed in the name)

(3a) each following line must have THREE values,
(3a i) EITHER use one line reading NULL NULL NULL or
(3a ii) use 2 or more lines of frequency,dB,LOG|LINEAR (LOG or LINEAR refers to the type of line joining the current point to the previous)

(3b) OR use any or all of NOTIFY DISTANCE LENGTH VERSION to imply notification on antenna change, AP distance or dipole length entry resp, or LISN for mains pickup.
OR use TEXT1 or TEXT2 followed by the notification title and body text resp. Study the examples.

- An antenna with NOTIFY will pop up an info box giving any TEXT entries when the user selects that antenna.
- An antenna with DISTANCE and/or LENGTH will pop up querey boxes to get A-P distance and/or dipole length from the user when that antenna is selected. To alter either, re-select the same antenna.
- An antenna with LISN will enable the LISN panel.

VERSION is for tracking updates - not yet active, but the idea is that a higher version no. will override a lower version of the same antenna, if one is loaded. The hardwired antennae are all version 0.

(4) MUST have an "END" line at the end.

(5) Presently there's a limit of 10 antenna factors in total

Example:

antenna #1

```
ANTENNA RF100
NOTIFY
TEXT1 "RF100 selected"
TEXT2 "RF100 near-field probe selected"
VERSION 0
NULL,NULL,NULL
END
```

antenna #2

```
ANTENNA RF200
NOTIFY
DISTANCE
TEXT1 "RF200 selected"
TEXT2 "RF200 antenna selected"
VERSION 0
        30000000   6 LINEAR
```

```
50000000   4 LINEAR
90000000 -11 LINEAR
130000000 -12 LINEAR
150000000   -9  LOG
210000000 -5  LOG
230000000  -1   LINEAR
280000000  -5  LOG
330000000  -1  LINEAR
470000000  3  LINEAR
500000000  5 LOG
END
```

Note: The data shown above may differ from the data in the actual file.

6.4.23 Calculate...Averaging

The Calculate menu allows selection of averaging to be applied to the current trace.
The average is calculated individually for each frequency point across the screen. If n averages are selected, the last n traces are averaged together. For each fresh average, the oldest trace is discarded.
Averaging is used for two purposes:
1. Where emissions (particularly conducted) may be pulsed, some standards specify the limit in terms of the average level of emissions. In this application, always use the highest number of averages.
2. When far field testing in an open field test site, use averaging to 'iron out' some of the variability in the background level both whilst recording background level and when measuring emissions from the UUT. (Backgrounds are never stable!).

6.4.24 Calculate...Peak

This mode applies a Peak hold function to the current trace. At each frequency point, the incoming values are compared with the corresponding values in the displayed trace. If the new value is greater than the currently displayed value, the new (greater) value is used. If the new value is less than or equal to the currently displayed value, it is discarded.
This mode is used in two ways:
1. If emissions are pulsed, and the repetition rate of the pulses is not known, Peak can show a worst case level of the emissions (see Quasi-Peak). If this gives a trace that is within the appropriate limit line, the user can be confident that the product conforms.
2. When far field testing in an open field test site, use Peak or Averaging when recording the background level. Averaging reduces the variability in the background level both whilst recording background level and when measuring emissions from the UUT. Using Peak when recording the background can give a 'cleaner' trace when the difference is subsequently being displayed.

6.4.25 Calculate...Quasi-peak

Quasi-peak levels are commonly specified for conducted emissions. It is used because conducted emissions are frequently pulsed in nature. Quasi-peak is a special form of averaging that gives a result in-between Peak levels and Average levels.
It can be computed from Peak levels if the repetition rate of the pulses is known. The Quasi-peak menu item provides a sub-menu to allow the user to enter this repetition rate.
Note that for continuous emissions, or emissions with a repetition rate above 10KHz, Peak, Quasi-peak and average give identical results.
If unsure of the repetition rate, connect an Oscilloscope to the output of the LISN and check for pulses of emissions. If these are present,measure the period between them and hence calculate the repetition rate. If the emissions are essentially continuous, or have a repetition rate over 10KHz, use Peak averaging mode instead.

6.4.26 Port

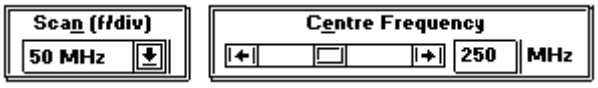
Menu item which allows selection of the serial port to be used for communication with the SA450B analyser.
Selection is either COM1 or COM2
The default is COM1.

If the user wishes to test the operation of the software without using the analyser, a Simulated item is included.

Simulated
Simulates the operation of the serial link to an analyser.
Allows the user to test the operation of the software without using the analyser.
This inputs data to the software as though it had come from an analyser. Simulated (Flat) allows the user to check antenna factor data entered as described in the Input...other section above. If this item is selected and one of the antennas selected in the Input menu, the correction characteristic will be plotted.

Port has Priority
On a few PCs, the interrupts are such that the mouse and serial ports conflict. This is no problem until the mouse is moved whilst the serial port is receiving a burst of data from the analyser. The data is corrupted and the I/O error message appears on the screen. To overcome this problem, selecting Port has Priority will disable the mouse whilst data is being received on the serial port.

6.5 Screen Controls



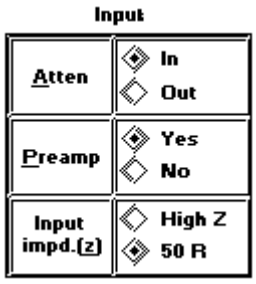
6.5.1 Scan
The scan control must be set to correspond to that set on the SA450B analyser. This, in conjunction with the Centre Frequency control sets the horizontal (Frequency) scaling on the screen.
Note that the software checks the Frequency range setting to ensure that the appropriate option list is available.

6.5.2 Centre Frequency
Allows the user to enter the centre frequency as set on the SA450B analyser. This should correspond to the LED display readout.
Increment buttons, slider bar and keyboard input are available.

6.5.3 Frequency Range
Selects either 450MHz or 4.5MHz to correspond to the setting on the analyser. The software cannot read the settings of the SA450B controls electronically, hence the user must accurately enter the settings manually in order for the screen to display the correct information and scale the traces properly.

6.5.4 I.F. Filter...Wide/narrow
The IF filter bandwidth in the SA450B analyser can be switched between 9KHz and 120KHz. These correspond to the filter bandwidths specified in the standards for emissions measurements.
9KHz is used for frequencies in the range 150KHz to 30MHz (conducted) and 120Khz is used for radiated emissions in the range 30MHz to 1GHz.
This switch must be set to correspond to the frequency range being measured.
The EMCE screen includes an option box to show the I.F. filter setting for information purposes. The setting of this switch does not affect the processing or display of the data.

6.5.5 Input Attenuator



Both the 450 and 4.5MHz inputs on the SA450B analyser are fitted with a switchable 20dB attenuator. These are used to extend the dynamic range of the analyser for large input signals. The EMCE screen includes a mouse driven option box to select the attenuator switch settings to match that of the analyser. This automatically adjusts the vertical scaling of the display.

6.5.6 Input Impedance

Two inputs are provided on the SA450B analyser for each frequency range. One is 50R impedance and the other is a high impedance input. For most RF work, the 50R input should be used. If using the analyser to monitor high impedance sources, or using it with scope probes to check circuit operation, use the high impedance input. This offers greater safety (protection) for the analyser input and allows monitoring of larger signals. The trade-off is generally lower sensitivity which varies with frequency. The EMCE screen has an attenuator options box to allow the user to select which input is in use. If High Impedance is selected, the software will adjust the vertical scaling to suit. NOTE that an additional ±15dB budget should be included in the error margin if taking measurements with the high impedance input.

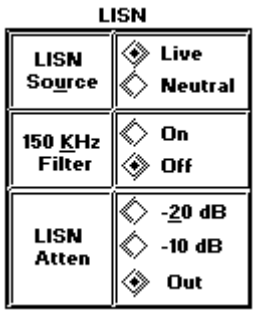
6.5.7 Pre-amplifier

If the SA1020 pre-amplifier is used to increase the signal level to the analyser, the preamplifier options box should be switched to YES. This will then automatically adjust the vertical scaling to match the increased gain of the system.
The nominal gain of the pre-amplifier is 18dB over the range 10KHz to 500MHz
NOTE: When using the RF200 antenna and invoking the RF200 under the input menu, this setting MUST be set to YES. (This is automatic on later versions of the software)

6.5.8 LISN - Source

Conducted emissions measurement requires the measurement of both live and neutral mains connections and the worst case used as the basis for assessing emission levels. The LISN1600 provides a selector switch with Live, Neutral and Off positions. A corresponding option box is provided on the EMCE screen LISN control area. This should be set in order to provide indication as to the signal source.
When a signal is not being measured, or when the UUT is being switched or connected, make sure that this switch is in the Off position.

6.5.9 LISN - Filter



Included in the LISN control area on the EMCE screen is a 150KHz filter IN/OUT control. This should be set manually to correspond with the switch setting on the LISN1600.
The 150KHz high pass filter is fitted to the signal output path of the LISN 1600. Always switch this filter IN unless the test specifically needs the measurement of frequencies below 150KHz. Although this is only a 2 pole filter giving a relatively slow roll-off, it has two benefits:

1. It reduces the level of low frequency (50Hz up to 2KHz) components in the signal which may be of high amplitude. This may be particularly useful in situations where there is high 50Hz mains harmonic content present on the supply. These can in extreme cases cause overloading of the analyser if not attenuated.
2. Most conducted emissions standards cover frequency ranges which start at 150KHz. Therefore frequencies below 150KHz are not relevant and by attenuating them, the useful dynamic range of the analyser is enhanced.

LISN - Attenuator
Set this to match the attenuator settings on the LISN. Note that if 0dB is selected, a warning message will appear. 0dB setting should normally never be used as this removes all transient protection for the pre-amplifier/analyser circuitry.

6.5.10 RUN/STOP

This controls the data acquisition and screen update operation. RUN causes the software to acquire data and update the screen continuously. Hot key “R” has the same effect. STOP reverses the action of RUN. Hot key for STOP is “S”.

6.5.11 S/SHOT
Takes one scan from the analyser and updates the screen once. Hot key “S”

6.5.12 C>S
Copies the current trace to the stored trace. Any data already in the stored trace will be lost. This is used to copy a background reading into the store so that the difference trace can be used to null out the background by subtracting the stored trace from the current trace.

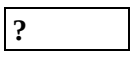
6.5.13 Scaling...Log/Lin
The horizontal frequency axis scaling can be switched between linear or logarithmic. Linear scaling can be used without restriction but log scaling requires specific settings to be made on the SA450B analyser. The EMCE software will prompt the user as to check these settings are correct before switching to log display.
The Log axes available and the corresponding settings are:

Log Range	Centre frequency	Scan	Freq. Range
30Mhz - 500MHz	250MHz	50MHz/div.	High
3MHz - 50MHz	25MHz	5MHz/div.	High
100KHz - 5MHz	2.5MHz	500KHz/div.	Low

Note that the SA450B analyser sweep is still linear and the log scaling is entirely done in software. This means that at the lower frequency end of the scale, frequency points are relatively wide spaced.

6.5.14 Scaling...dBm/dBuV
The vertical scaling of the spectrum amplitude can be switched between dBm and dBuV. For EMC emissions applications, dBuV is commonly used. For other general RF analyser work, dBm is frequently used.

6.5.15 Information screen



The ‘?’ button (lower LHS of graphics screen) shows the current settings, any comments fields and AF data plot. The Antenna factor button toggles this plot between full 30-500MHz plot and the frequency range currently in use. Note that "staircasing" reflects the graph's sometimes vastly expanded y scale and doesn't imply any steps coarser than the instrument's resolution in the actual AF.

6.5.16 Power up defaults
All the program defaults are saved in a file called EMC.INI located in the emc_eng directory. This is a simple text file which can be edited with any standard word processing software. Every time the EMC software is run, the program reads this file and invokes the settings defined in it. The file is fully commented and self explanatory. Default settings such as Port selection, limit line selection, analyser configuration etc.. may be set to suit your own circumstances.

7.0 Operating notes

7.1 Frequency Measurement

The frequency of any particular peak emission can be accurately measured on the analyser. The technique uses the fact that the centre frequency display is a calibrated readout with a reference derived from a stable crystal oscillator.
To measure a frequency, bring the peak of interest to the centre of the EMCE screen using the coarse and fine centre frequency adjust controls. When at centre screen, reduce the scan control gradually, keeping the relevant peak centre screen by fine adjustment, until the peak has expanded to one or two divisions wide. Then read off the centre frequency display, this will now be showing the frequency of the peak.

7.2 Frequency resolution

Resolution is determined by the I.F. filter bandwidth. At the Wide setting on the analyser this is 120KHz which means that any emissions less than 120KHz apart will not be separated (i.e. shown as separate peaks).
If Narrow bandwidth (9KHz) is selected on the analyser, resolution will be 9KHz. Note that the EMCE software has no effect on the resolution, the pixel density being more than adequate to fully show all the detail available from the analyser.

7.3 Frequency axis

The frequency axis is controlled by the Centre frequency settings and the pull-down scan selection menu on the EMCE screen. Note that all these controls are completely independent of the analyser controls. The user must ensure that the software settings match those on the analyser otherwise the results could be extremely misleading!
The frequency axis can be switched between linear or logarithmic scaling by clicking on the button in the bottom RH corner of the display. Log scaling is frequently used to plot limit lines in the published standards and so may be the preferred format for comparison with limits.
Three ‘fixed’ log axes are possible. Low (150KHz - 5MHz), Intermediate (1MHz - 50MHz) and high (30MHz -500MHz). Each requires the analyser frequency controls to be set in a specific way. These settings are displayed to the user when any log axis is selected. Once selected, the frequency control settings cannot be changed unless the axis is switched back to Linear.

7.4 Peak amplitude measurement

It is important to remember that in order to measure the true magnitude of any peak, the display must be ‘zoomed in’ to either 500KHz/div (HF range) or 50KHz/div (LF range). Wider span settings are fine for obtaining the general overview and an approximate idea of amplitudes. Therefore if you need to measure true peak heights for comparison with limit levels (for example) the always ‘zoom in’ to each peak to be measured.

7.5 Clipboard

EMCE software is fully Windows compatible and has full Clipboard facilities. This means that you can ‘capture’ any screen and copy it direct to your word processing document which can be running in the background. Thus you can build up your test documentation whilst conducting the tests.

To copy the screen to the clipboard, press ALT+Printscreen.

To switch between EMCE software and your document, use ALT+TAB.

To copy the screen into your document, use paste (CTRL+V) in many applications.

7.6 Testing for emissions

7.6.1 Radiated emissions testing.

In order to ensure repeatability and consistency of measurement, the technique used to measure radiated emissions is carefully defined (in theory!!)
In practice, radiated emissions are difficult to measure accurately. To minimise the variability of measurement, emissions are measured in the 'far field', far enough away from the unit under test to avoid field distortions immediately in the vicinity of the source and to avoid the need to distinguish between E or H field sources.

Techniques for Far Field radiated testing are set down in the Standards which propose 2 alternative techniques:

Open field test site: Literally do the measurements in an open space, well away from interfering sources or any structures that could give rise to reflections.

Test cell: This comprises a totally screened room fitted internally with RF absorbent materials (cones) to prevent reflections. This eliminates background radiation but is an expensive solution and only test houses and large organisations are able to afford these.

The use of far field measurement enables the user to gain an overall picture of the emission levels and to spot any potential 'problem' frequencies.
The near field probes can then be used to locate the hot spots or leakage paths corresponding to the problem frequencies. Once a product has been 'refined', the far field test can be repeated to quantify the effect of the improvement and to ensure that new problem frequencies have not appeared.
Note that the combination of near and far field testing is essential.
Far field testing is how the product is tested for compliance. This is the only relevant test capable of comparison with the emission limits. Far field testing can give no information about the source of the radiation from your product.
Near field testing enables you to track down the source and to 'fix' it. Measurements can only be relative and will not bear any defined relationship with the far field measurements. Strong 'hot spots' as measured by the near field probes will not necessarily produce strong far field 'peaks'. This is why near field probes when used in isolation are of limited value.

7.6.2 Open Area Test Site (OATS)

Sometimes called an Open Field Test facility
This is literally an 'open' field i.e. an area free of any metal objects or structures which could cause reflections. The site must be 'calibrated' so that the amount of background radiation is known and can be allowed for. See Test site calibration. The nature of the ground also has an effect because of the variability of the ground reflected radiation. In order to obtain consistency, a metal ground plane should be laid on the ground between the product and the antenna. This should be such that it provides a totally reflecting surface (whereas ordinary 'ground' e.g. soil, will have an indeterminate reflection coefficient which will vary with weather and time of day). Having a reflecting ground plane may give consistent results but the reflected radiation itself causes other problems. The antenna will 'see' the resultant field strength due to the direct radiation and the reflected radiation. If the distance travelled by the reflected radiation is half wavelength then the two signals will cancel at the antenna location and the analyser will measure a level far below the true figure. In order to overcome this effect, the standards specify use of an antenna mounted on a mast such that it can be adjusted in height up to 4 metres and, at each frequency of interest, the antenna height is adjusted until a peak level is found. At this point the direct and reflected signals are in phase and sum together. To calibrate the reading of emission levels in a non-ideal site, use an ERS (Emissions reference source).

7.6.3 Test cell

This comprises a totally screened room fitted internally with RF absorbent materials (cones) to prevent reflections. This eliminates background radiation but is an expensive solution and only test houses and large organisations are able to afford these.

Note that a simple screened room may be the worst option because the RF radiated by the unit under test will reflect from the walls/floor/roof of the room, summing in some positions and cancelling in others, making any true measurements virtually impossible. However, use of a calibration source (see ERS, section 7.16) will enable the room to be calibrated and a correction factor calculated for all frequencies of interest.

7.6.4 Radiated testing strategy:

A cost effective strategy would be to use the Laplace equipment to identify and reduce all significant emissions from a product. If the emissions are well below the limit lines and the site is either properly designed or is calibrated with an ERS then self certification would be in order.
This will require far field testing followed by the use of the near field probes to track down sources and leakage paths.
If using the RF200 antenna and if a reasonable test site can be established, a measurement of emission levels is possible and this can be compared with the appropriate limits.
For greater confidence, either use a calibrator such as the ERS or a product can be taken to a test house and the emissions accurately measured. Using the same produce and testing it in exactly the same configuration back at your own test site with this Pre-compliance equipment, the test house results can be used to 'calibrate' your own site by correlation. Now you can measure emissions from your other products with an increased level of confidence in the results.

7.6.5 Environment - Radiated Testing

The technique specified by the EC standards for measuring RF emissions is to measure the far field radiation (field strength) at a specified distance.

Measurement of absolute field strength is generally difficult because so many factors can substantially affect the results. For instance the effect of background radiation is always present unless you have a completely screened room.
If you have a screened room, the effect of reflections will lead to gross errors unless the walls, ceiling and floor are fitted with a system for absorbing rf energy. (Absorbent 'cones' etc.)
Open field test sites avoid screened room problems, but will be affected by any metallic structures/objects in the immediate vicinity.
The nature and condition of the ground will have an effect.
The location of the receiving antenna relative to the UUT must be such that it measures worst case levels. (E.g. the UUT may radiate higher levels from the back than from the sides or the front)
The antenna itself will modify the readings due to changes in sensitivity with frequency (antenna factor).

Clearly, precision measurements of the type that most engineers are content with are simply not possible. Even test houses will admit that field strength measurements are sometimes more of an art than a science and the same unit measured in two test houses will give different (but *usually* similar) results. So even the experts struggle!

The object of the exercise is to minimise the errors so that you can obtain an approximation of the relative EMC radiation levels emitted by your product.
Note that this overview applies to all EMC test equipment, even the most expensive, because most of the problems are associated with the environment over which we have no control.

7.7 Near Field measurements.

The RF100 Near field probe set enables you to detect radiation sources precisely. Note that the output from these probes will reflect the intensity of the source. This often does NOT correspond to the peak frequencies as measured by the far field antennas. See Field types. Bearing in mind that it is only the far field that matters ('cause that is what is measured in a test house), you must use the far field results to identify the 'problem' frequencies and then concentrate on just these frequencies when in near field mode. See Audio Demodulator

The probes can initially be used with the analyser set to cover a broad spectrum to get an idea of the emission levels at specific points outside and inside the UUT. Because the levels are totally dependant on the proximity of the probe to the source, any measurement of absolute field strength is quite meaningless.
Note that the significant emission frequencies normally do **not** correspond to clock frequencies because clocks are usually very low power circuits and much of the digital circuitry is driven at harmonics or sub-multiples of the basic clock frequency.

7.8 Radiated test technique

This section describes how to check radiated emissions from a typical product.

Test Site

As the previous sections have stated, establishing a suitable test site is of prime importance. Guidance is given both in this manual, books such as written by Tim Williams and Chris Marshman and as specified in the Standards themselves.
For the purposes of this section, we will assume that a site has been established that at least attempts to match the basic requirements of an OATS in respect of using an area free of reflecting metal surfaces.

Configuration

If the product is table top mounted, it must be placed on a non-conductive table 0.8m high, connected as specified in the appropriate Standard.
The antenna (RF200) should be placed at a known distance from the product in horizontal polarisation and pointed at the product. For most applications, the minimum distance of 3m can be used. If using the Dipole, set the elements to maximum extension.
Establish the analyser and PC as far as practicable off to one side of the antenna.
Couple the pre-amp input to the antenna and the output via coax cable to the analyser.
Set the analyser and PC to display 0 - 500MHz using the 450MHz range input, 50MHz/cm and 250MHz centre frequency. Set the analyser **Filter** switch to **OUT**.
Use only the current trace for the moment.
Set Bandwidth to wide and switch the pre-amp on and RUN the PC acquisition.
Under the Input menu, select the appropriate antenna (RF200 or RF500) and enter antenna distance and dipole element length if requested.
Find the slowest sweep rate that provides consistent operation by starting at the clockwise end of the control and gradually adjusting it anti-clockwise. If the display becomes unstable turn the control back slightly clockwise to regain stability.

Check background

With the UUT switched off, check the spectrum on the PC screen with the input attenuator switched IN. Then check that when the attenuator is switched OUT, all significant peaks increase by 2 divisions (20dB). If the peaks are more than half way up the screen with the attenuator switched IN, it is likely that the analyser will be in compression when the attenuator is switch OUT. If this happens then the test site is unsuitable due to high background emissions and an alternative needs to be found (your back garden at home, for instance)
Continue with the attenuator switched OUT.

Background nulling

Because the background needs to be stable for nulling purposes, set the averaging to 16 or 32 to establish a stable display. When stability is gained, click on the C->B button and switch the Diff trace on and the Curr trace off. The red diff trace will now be basically ‘clean’ but will show intermittent peaks as the background varies.

Locating problem frequencies

Switch the UUT on.
Due to the averaging (still 16 or 32) any emissions from the product will take time to show on the screen. They will appear as consistent peaks in contrast to the intermittent background variations. If unsure, switch the UUT off and check that the suspect peaks now disappear.

Having identified those peaks which originate from the UUT, turn on the Curr trace and by correlation between the Diff and current traces identify those peaks in the Curr trace that originate from the UUT.
The Diff trace has now done its job in locating peaks which originate from the UUT in amongst the background. Note their frequencies and/or store the results to disk/hardcopy.

Measurement of emission level.
First the appropriate limit line can be enabled. Select the relevant limit line from the Limits menu and switch the limit line on. Note that at this stage comparisons between peak heights and the limit line will be misleading. Each emission peak from the UUT must be measured separately by bringing it to centre screen and 'zooming' in to measure its full amplitude.
To do this:.... Pick which emission peak from the UUT you wish to measure.
If using the RF500 Dipole, tune the antenna to the relevant frequency
Switch off averaging.
Switch off the Diff trace
Use the Centre Frequency controls to bring the peak to centre screen.
Use the scan mode switch to zoom down to 1MHz/cm, adjusting the centre frequency controls as necessary to keep the peak in centre screen. The peak should now show a higher level than when 'zoomed out'.
If you have set the software settings are correctly, the peak magnitude will can now be compared with the limit line, bearing in mind the margin of uncertainty due to the instrumentation and antenna (±6dB) and the test site (??dB). Use of the ERS calibrator will considerably reduce this uncertainty.
Repeat for all other UUT peaks
Repeat for vertical polarisation

7.9 Problem assessment and monitoring modifications

Many sources are found to be related to cables and any other wiring that exits the UUT, including the mains lead, if fitted. Again, the near field probe will help track this down.
Once the source is located, steps can be taken to reduce the emissions, either by PCB redesign, circuit changes, filtering or screening. The near field probes can be quite effective in monitoring the effectiveness of these actions by performing before/after tests. The main factor to be aware of is that the levels as measured are very dependant on the precise location of the probe. You can use the Dipole stand to hold the probe in a fixed location whilst changes are made to the UUT. To facilitate this, the stand accessories include an adapter sleeve to allow a probe to be held in the clamp at the end of the boom.

Note that in general, a given reduction in signal as measured by the near field probe will give the same reduction in the far field. (i.e. a 10dB reduction as measured by an H field probe will give an approximate reduction of 10dB in the far field.)

When you have completed 'improvements' to the UUT, repeat the far field measurements to check that the improvements have been sufficient and to ensure that no other peaks have been created or made worse as a consequence of the changes to the circuitry/screening.

7.10 Conducted emissions

A very significant element of the standards is mains conducted emissions. These have been subject to restriction and testing because harmonic distortion (up to 39th harmonic) and high frequency distortion (from a few 10s of KHz to the 100s of KHz) are becoming significant problems. For all mains powered equipment, the standards call for the amount of interference conducted back up the mains cable to be limited.

The SA450B and the LISN1600 which are designed to cover the higher frequency emissions, from 10KHz up to 30MHz as specified by EN standards.
Measurement of RF on a mains supply cable introduces specific problems. In particular these are:
(A) High voltage (240V, 50Hz)
(B) Presence of interference from other sources coming 'up' the mains.

(C) Variable impedance as seen by the UUT (Unit Under Test) looking back down the mains lead. The source impedance of the mains varies considerably at RF frequencies from one location to another, making repeatable measurement impossible.
To overcome these problems, CISPR have specified a Line Impedance Stabilisation Network (LISN) to be used for all mains interference measurements. The construction and components are clearly specified so that all conforming LISNs will give the same results.

7.11 Pulsed emissions

Many emissions output from equipment down the mains lead are pulsed in nature. Often these will pulse at 100Hz, caused by zero-crossing control circuitry. These pulsed emissions will modulate the frequency scan of the analyser at different points on successive scans, giving the effect of apparently random spectra, or 'travelling' artefacts, especially when using the low frequency ranges. This is a well known problem that affects all conventional spectrum analysers and is overcome by using the 'Peak' or 'Quasi-Peak' modes on the PC software. This will cause the envelope of the emission spectrum to be drawn by recording the peak levels over a succession of scans. Let the picture build up until it becomes apparent that there are no more 'gaps' left. You will then have the spectrum of the pulsed emissions.

7.12 Quasi-peak analysis

Some standards call for 'quasi-peak' detection. This technique will give a lower reading spectrum than the 'peak' technique used above. The reduction actually depends on the repetition rate of the pulses and is shown graphically on page 55 of Tim Williams' book (Page 65 in the second edition). This shows that for 100 Hz repetition rate, the difference between peak and quasi-peak is 7dB for the frequency range below 30MHz and 12dB for the frequency range above 30MHz. At higher repetition rates the errors reduce. The graph also shows how Average readings relate to Peak, thus by measuring both peak and average, and relating the two on the graph, the repetition rate can be derived. When using the Q-P option in the EMCE software, the repetition rate will be requested. In many instances this will be known (for instance, light dimmers use phase angle controllers which produce pulses at a 100Hz repetition rate). If not sure, observe the output of the LISN with a scope to measure the repetition rate between pulses. If the emissions are essentially continuous, use Peak detection or enter a repetition rate of 10,000Hz.
An important point is that if the 'peak' levels as measured from your UUT are within the limits specified by the standard, you know that you have erred on the safe side.

7.13 LISN - Background interference

At some locations, low frequency (<100KHz) artefacts may appear, even when no UUT is connected to the LISN. These will occur if the mains supply has such a high harmonic content that the filtering in the LISN is unable to attenuate it fully. Using the 150KHz high pass filter on the LISN will help, but this is really a symptom of very poor local mains supply conditions.

7.14 Insertion loss

Part of the requirements of certain directives (e.g. EN 55 015) includes a measurement of 'insertion loss'. This is a measure of the effectiveness of an RF filter and requires the measurement and comparison of both the input signal to the filter and the output signal from the filter, the difference between the two being the 'insertion loss'. Conventionally, this is measured at many discrete frequencies using a sine wave signal generator and an RF voltmeter, a time consuming and far from ideal technique.
With the SA450B and PC interface the complete insertion loss characteristic can be measured easily and accurately for all frequencies in the required range, instead of just a few discrete frequencies. The test will require a set-up as defined in the standard 55015, section 4.1, section 5 and fig 3 plus either a swept sinewave signal generator or a 'white' noise source covering the frequency range 150KHz to 1605KHz.

1. Connect the input of the filter to an appropriate source. This can be either a broadband noise generator or a swept sine wave generator. The sweep may be automatic or manual. The signal level input to the filter must be set to the level specified in the standards.
2. The output of the RF filter is then measured. Connect the analyser to the filter output. If using a swept sine wave then use Peak averaging and sweep the source very slowly. Expect to take many

minutes to complete the sweep. Too fast a sweep will result in obvious gaps in the spectrum on the screen. If sweeping manually, monitor the screen to check progress. If using a broadband noise source then use 16 or 32 averages. This builds up a spectrum of the output from the circuit under test..

Copy the resultant spectrum to the red trace. (F2) or C>S

3. The input to the analyser is now connected to the filter input and the measurement repeated except that the new spectrum, once acquired, is not copied to the red trace.
4. Select Diff trace or input minus red trace (F5) and the insertion loss characteristic is immediately shown across the whole range of frequencies tested. The scaling is 10dB attenuation (loss) per div. with 0dB at the bottom. So if at one particular frequency, the line is 4½divs up from the bottom, the insertion loss is 45dB at that frequency.

7.15 Dipole or broadband antenna, which to use?

EN50022 specifies that a tuned dipole be used as the antenna for radiated emissions testing. The dipole is a basic standard that, at its tuned frequency, has an easily definable output vs field strength characteristic. Dipoles are tuned by adjusting the length of each element to be ¼wavelength long. If measuring the emissions from a product over a wide frequency range, this is tedious, time consuming and is a source of error. Broadband antennas have a known response over a wide range of frequencies and need no adjustment. The response is not flat, and all broadband antennas should be supplied with an 'antenna factor' curve. This is a plot of sensitivity vs frequency over the full working range of the antenna. The RF200 has a working range of 30MHz to 1GHz and thus matches the requirements of the EN standards.
Both RF500 and RF200 may be used with any analyser or receiver but the SA1020 pre-amplifier should be used to ensure that the characteristics of the antenna match the published data.
As regards which should be specified, it really depends on the type of work you wish to undertake. Basically, you need the Broadband antenna if it is necessary to measure absolute field strength with a reasonable level of confidence and have an effective test site, free of reflections.
If you are only using the test kit to measure relative levels then the Dipole is an ideal low cost alternative because the Q of the dipole antenna is relatively low. Although maximum sensitivity is reached at the tuned frequency, the dipole is quite effective as a broadband antenna and so for pre-qualification testing and all comparison checks it is quite adequate.
Note that the antenna factor for the RF200 is included in the Windows version of the SA1030 software.
This new antenna means that you can cover the whole radiated emissions frequency range in one sweep. No need to adjust dipoles to each frequency of interest, no need to switch between log periodic and biconical types half way through the testing.

7.16 ERS calibrator (Emissions reference source)

In spite of careful planning of the test site and rigorous test procedures, there will always be a significant element of uncertainty about the accuracy of absolute field strength measurement when conducting far field emissions testing. The ideal solution would be to have a known, calibrated source of emissions. The ERS is just such a source. This is available as a option for the RF-Kxx range of kits. It is a small self-contained unit with battery and antenna which radiates a white noise, stable broadband signal. The level of field produced by this source at 3m and 10m is measured and plotted on a true test site and these test plots (calibration curves) are included with the unit. By comparison between the results obtained on your own test site and the calibration curves, a true correction for your own results can be obtained.

7.16.1 Use of the ERS

The ERS can be used in two ways:
(a) To produce a correction data file for the test site across the whole frequency spectrum and enter this as an antenna factor plot using one of the entries in the INPUT menu. This requires more work

initially but may be quicker in the long run. The dissadvantage is that test site conditions may vary and different test products may affect the calibration of the site.
(b) To check individual peaks during the course of testing a product and apply the correction unique to each measurement. This is easier and quicker and has the advantage of being right every time, irrespective of any variation in the test site or UUT. Also, for larger products, the location of the source will be a factor in the far field measurement. Using this technique allows the ERS to be located as close as possible to the source, avoiding another source of error.

Technique (a) Once a test site is established and ready for use, the ERS is positioned at the location of the product to be tested (if the product is small it is removed from the site for the purposes of this test , if too large to remove, the ERS may need to be locationed at various positions which may be liable to be sources of emissions)
Set the analyser to the full 500MHz span.
Set the Input Menu selection to Direct.
With the ERS switched off, use Peak detection to acquire the background spectrum and copy this to store.
Switch the ERS on and acquire the resultant spectrum. Note that the ERS is a strong source and will, in general, 'drown out' the background.
Once the ERS spectrum is on screen it can be compared with the appropriate calibration curve. Four curves are provided, vertical and horizontal polarisation at 3m and 10m.
From this comparison, derive a series of data points (Freq vs dB) which will adjust the spectrum on your screen to agree with the calibrated data. Fig 16 shows an example of how such a table is created. Note that an extra column has been added to adjust the results by -8dB. This is to allow for the error caused by the fact that the 50MHz/cm scan mode (rather than a reduced scan mode setting as required for accurate measurements) is used.
The data produced in columns A and E can then be entered into the EMCE software using the A.F. user entry procedure described in 6.4.22. It is recommended that you modify one of the existing 'example' files rather than writing a new 'antenna' and that the 'standard' A.F. data (the first 5) are left untouched.
If wishing to display limit lines, use the DISTANCE command in the A.F. file.
You will need to repeat this excercise twice to create two files, one for vertical and one for horizontal orientation.
Fig 16

A	**B**	**C**	**D**	**E**
Freq. MHz	Direct result (dBuV)	Calibration curve (dBuV)	Correction C-B (dB)	Adjustment (-8dB)
30	45	35	-10	-18
50	40	40	0	-8
65	40	44	4	-4
100	42	50	8	0
120	41	52	11	3
160	49	55	6	-1
.....	.....	....	....	....
....	.....	....	....	....

Once the data is entered, it can be checked by 'measuring' the ERS emissions and confirming that the resukts are similar to the calibration data, less 8dB.
Subsequently, when 'zoomed in' to examine a particular peak from a product, the ERS can be used again to check the accuracy of the reading.

Technique (b) Proceed with the radiated testing using the techniques explained in section 7.8 using a 3m test site and an antenna height of 1.5m.
When a suspect peak is found, 'zoom' in on this peak to a scan mode of 1MHz/div. and note the level in dBuV (and/or save the result to file). Place the ERS as close as possible to the source. Use the near field probes if required to locate the source. With the ERS at the source, switch the ERS on.
Switch the software to read peak level (Calculate menu). Note the reading due to the ERS and compare this reading with the appropriate ERS calibration curve. (Vertical or Horizontal). There will probably be a difference in readings at the frequency of interest. This difference must be applied to the

reading obtained from the UUT. For instance if the analyser reads 46dBuV from the ERS, and the ERS calibration plot reads 57dBuV at that frequency, then the analyser is reading 11dB low, so 11dB must be added to the result from the UUT.

g8.0 EMC

EMC stands for **E**lectro **M**agnetic **C**ompliance.
In plain English, this is a measure of the product's ability to cause interference (Emissions) and its ability to withstand interference (Susceptibility).
Interference is a BAD thing. At the 'trivial' level it causes annoyance on radio and TV channels. In other circumstances it can cause life threatening 'incidents', such as interference to aircraft control or navigation systems.
Unfortunately, interference is a fact of modern life. All electrical/electronic systems (from the National grid to an electronic wristwatch) radiate interference at some level. Therefore, the ability of a product to work properly in the presence of 'normal' interference is just as important as having its emissions limited.
So there are two parts to EMC, **Susceptibility** and **Emissions.**

8.1 Emissions

Emissions are any form of electrical/electronic signal emitted by the product but which is not an intended function. This covers radiated interference (radiated emissions) and interference transmitted along any cables or wires connected to the product, including mains leads (mains conducted emissions).

In general, all the above relates to frequencies in the range 9KHz to 30MHz for conducted (i.e. transmitted back down the mains lead) and 30MHz to 1GHz for radiated.

8.2 Susceptibility

Susceptability is a measure of a product's ability not to malfunction when subject to any form of electrical interference. This includes:
» radiated interference (radio etc.),
» conducted interference (along mains cables, signal and control leads etc.)
» electrostatic discharge (such as may happen if you walk across a carpeted floor and touch the product).

8.3 Radiated field types

Radiated fields (or interference) are electromagnetic waves emitted from a conductor (PCB track or wire) acting as an **aerial** which is being driven from a **source**. The source is generally an electronic circuit or component generating ac signals or having fast edges with high frequency components. A source in isolation cannot create any significant radiation unless it is connected to an aerial.
For an aerial to be effective, it must have dimensions approaching ¼ wavelength of the frequency emitted.
Conductors acting as aerials may be low impedance (current) sources or high impedance (electrostatic) sources. Open circuit conductors will be the latter and circuit interconnections, including power rails on PCBs will be the former. In fact, the bulk of emissions from electronic circuits tend to be from low impedance (current) sources. These give rise to magnetic (or H) fields in their immediate vicinity. Electrostatic sources create corresponding E fields. The RF100 Near Field Probe kit includes both E and H field probes, each designed to be sensitive to the high local field strength immediately adjacent to a source. This region is known as the Near Field.
As a field radiates away from a source it undergoes a transition to an alternating E and H field (electro-magnetic) wave which has an impedance corresponding to that of free space (377ohm). In this condition, it is called Far Field radiation. The transition from near to far field takes place gradually, but it is generally accepted that the borderline occurs at a distance of approximately $\lambda/_6$ (one sixth of a wavelength). At 100MHz this is 0.5m.

8.4 Field Strength

This is the parameter that is used as a measure of the level of emissions from a product. It must be measured at some distance from the source in order to avoid the unavoidable distortions that occur close to the source. It is measured in dBuV/m which is related to the intensity of the electric component of the radiation. uV/m is a simple voltage gradient parameter and dB (log) scaling is used so that a wide range of field strengths can be plotted sensibly on one scale.

In the far field (i.e. when the energy alternates equally between magnetic and electric fields), there is a fixed relationship between the two field types (defined by the free space impedance). This means that measurement of the electric field gives a reliable figure for the total energy in the radiation. In the near field, the relationship is undefined and measurement of the electric field would not give a reliable result.
Hence the importance of measuring emissions using far field techniques.

8.5 Wavelength

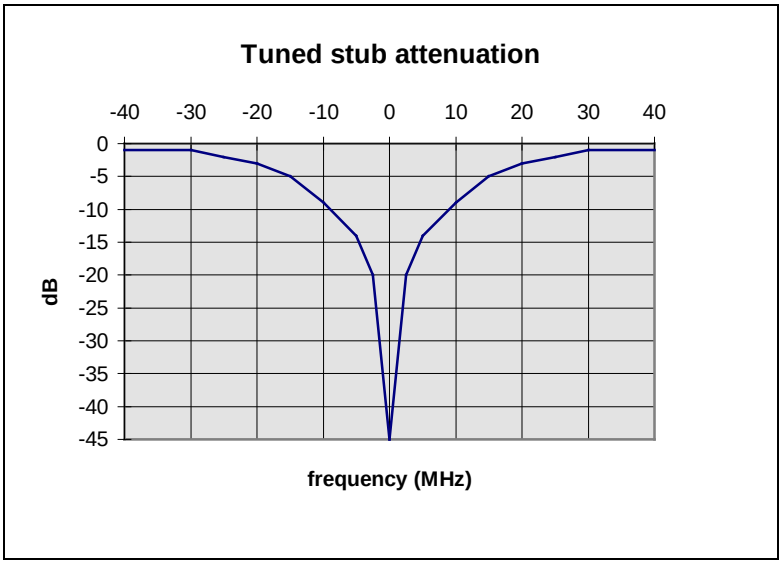
An awareness of wavelength is very useful in EMC work. Frequency and wavelength are inversely proportional and an easy number to remember is that the wavelength at 100MHz is 3 metres. So 50MHz has a wavelength of 6 metres and 300MHz has a wavelength of 1 metre.

Effective transmitters have a length of quarter wavelength so a cable or PCB track 250mm long will radiate effectively frequencies around 300MHz. This effect is sometimes seen when, for instance, digitally clocked signals are present on a data bus. Although the clock frequency may be 12MHz, emissions apparently peak at 300MHz. The reason is that although a complete spectrum of odd harmonics of 12 MHz is present on the bus, the physical length of the tracks provides effective radiation only at 300MHz.
This example highlights one reason why far field testing rather than near field measurements are the basis for the standards. With a near field probe, the whole spectrum of harmonics would be detected, probably showing highest levels at the fundamental and lower harmonics. The 300MHz peak may not be apparent even though this is the main problem in terms of radiated interference. Near field probes respond to source intensity, not radiation effectiveness.

8.6 Dealing with single background peaks

Sometimes an otherwise acceptable site has one large peak in the background radiation which is powerful enough to push the analyser into compression when the input attenuator is switched out. This peak may be due to proximity to an FM broadcast station or BT paging service (153.5MHz) for instance. If this occurs, all is not lost!
A trick well known by radio amatuers is to use a ‘stub’ as a notch filter. These filters give a very sharp attenuation to just one frequency (and odd multiples). Attenuation factors over 40 dB can be achieved over a narrow bandwidth without affecting the levels in the passband.
To make a ‘stub’, use a BNC Tee adaptor in the antenna lead to join a length of co-ax to this lead. This co-ax should be cut to ¼ wavelength of the problem peak and left open circuit at the free end. The best way to do this is to initially have a length too long and gradually snip bits off, observing the results on the screen, until the desired frequency is reached. Note that the actual length will differ from the calculated length due to the characteristics of the co-ax.

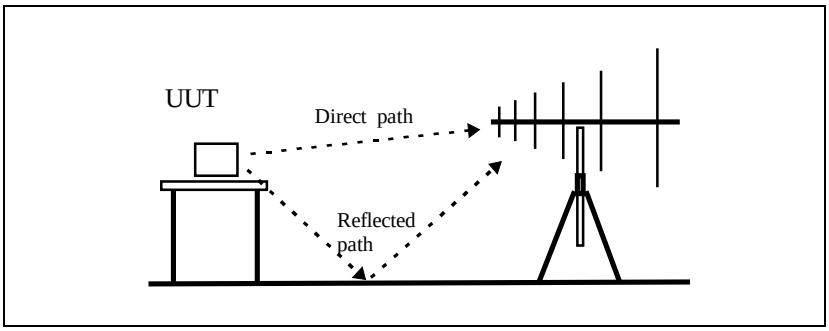
Fig 17 Attenuation characteristic for tuned stub



8.7 Ground plane

In general, any UUT will emit radiation in all directions. Some of this will impinge on the ground which will partially reflect this radiation.
When measuring emissions in the far field, the signal received by the antenna will comprise a direct signal and a signal which has been reflected from the ground. (Assuming that the test site has been chosen so that no other reflections are present).

Fig 18 Ground plane reflection



The amount of this reflected signal depends on ground conditions and may vary very considerably in amplitude. On 'soft' ground such as earth (soil) the reflection will vary from day to day as conditions change. This means that the integrity and consistency of the results will be variable. To overcome this problem, the standards require a test site to have a metal ground plane consisting of a continuous metal sheet (or equivalent) under the UUT and between the UUT and the antenna. This gives a consistent 100% reflection. This is in one sense 'worst case' because the effect of the reflection will be maximised, but at least it will be consistant.
The effect of the reflection will depend on frequency and the difference in path length between the direct path and the reflected path. If this difference is equal to half a wavelength at the frquency of interest, the two signals will be 180° out of phase and will cancel, producing up to 20dB reduction in signal strength.

To overcome this effect, the standards call for the antenna to be mounted on a mast so that it can be varied in height over a range of 1 to 4 metres. For each frequency there will be a height at which the two signals are in phase and additive. This is the height at which that frequency is measured.
If using an open field site on dry soil, the reflection will be small and the gain/attenuation effect will be minimal.

8.8 Test Site Calibration

Any area or test cell used for far field radiation testing should be calibrated. Purpose made cells such as a G-TEM cells are supplied ready with a calibration sheet which defines the characteristic relationship between UUT emissions and cell output vs frequency.
If using a an open field test site, this should also be calibrated. The ground plane reflection alone can have a significant effect on the test results. One way of achieving a rough calibration is to test a product with known emissions (i.e. one which has already been tested at a test house) on your test site under exactly the same conditions as applied during the test house measurement. By correlation of your results with the test house results, an approximate calibration of the site can be derived. A better technique is to use a calibrated noise emitter.(ERS). Details of this are given in section 7.16. Note that if the site is outdoors, it will need a calibration check every time it is used because weather conditions can affect the site significantly.

8.9 The Legislation

EC legislation is embodied in Council Directive 89/336/EEC which is intended to limit the interference caused by electronic and electrical products. A series of EN Standards define limits for

emissions and the levels of interference (RF radiation, mains disturbances and static discharge) for susceptibility tests. If a product can be proved to comply with these standards, the product can be issued with a compliance certificate and a CE label attached. This certification has legal validity throughout the EC and in those countries which used to be part of the EFTA group.

After 1st January 1996, all products offered for sale within the EC which fall within the scope of the directive must have an EMC compliance certificate. Failure to do so will result in the product being removed from the market and possible conviction of those responsible. The consequences of false certification can be severe!

The responsibility for obtaining certification rests solely with the person/organisation placing the product on the market within the EC. If the product is imported from outside the EC, liability still rests with whoever is placing it on the market in the EC, not the manufacturer. Note that the supplier cannot pass the responsibility to a 'test house'. The function of a test house is simply to take the measurements, it is up to the responsible person to make the final decision regarding compliance.

8.10 Scope.....What products are affected?

Any product which uses electricity in any form is included, except those which "have no intrinsic function".
This means that the only items excluded are those which, on their own, are completely passive and serve no function. These include components such as resistors, integrated circuit chips, relays and connectors.
However, any assembly, such as an assembled printed circuit board, which is sold as a separate item, must conform. This means that any adapter cards and plug-in cards for PCs must be certified.
Items such as electric motors which are sold only as a component part for inclusion into other products still must conform because they are sold as a product with an intrinsic function.

When are they affected?
The rules state that when a product is 'placed on the market' or 'put into service', it must be compliant. The person/organisation responsible for the compliance is that person/organisation that 'places it on the market' or 'puts it into service'. If you do not sell it, but make it yourself and use it within your own factory (e.g. some process control equipment or an electronic test unit) then it still must comply.

8.11 Certification

Most manufacturers have a choice of two routes, **self certification** and **TCF (Technical Construction File).**
The TCF is provided for those products that cannot be tested in the conventional way or for which no specific standard applies. Such products may be power stations and other large installations. A file is created which covers all the design considerations, calculations, protective features, test results, component specifications etc. which would justify a claim for compliance. This has to be audited by a 'competent body' (an organisation approved by NAMAS to fulfil this function) who will charge you for the privilege. The TCF route is likely to be both time consuming and expensive.
Self certification is exactly what the name implies. **You** issue a certificate that states that product XYZ complies with the relevant directives and **you** sign it. Of course, before doing that you should take all reasonable steps to ensure compliance (in terms of product design) and make any appropriate tests for compliance as a check. What these tests should comprise is at your discretion. At the end of the day, you must be prepared to stand up in court to argue your case but, provided that you had acted in such a way as to show due diligence, you should have nothing to fear.

8.12 The Standards

In the UK the Standards are published and issued by BSI Standards. Assistance in deciding which Standards apply to your particular product can be obtained from the DTI and/or your local EMC Club
Contact points: DTI Tel: 0117 944 4888
Fax 0171 215 1529/2909

BSI Tel 01908 221166

As a very rough guide, the current EMC standards for Emissions which have been issued are:

Cenelec Reference	**Equipment covered**
EN55011	Industrial, Scientific and Medical Equip. (ISM)
EN55013	Sound & TV broadcast receivers
EN55014	Household appliances and portable tools
EN55015	Fluorescent lights and Luminaires
EN55022	Information Technology Equipment (ITE)
EN50065-1	Mains signalling equipment
EN50081-1	Generic standard - Light industrial and domestic
EN50081-2	Generic standard - Heavy industrial (generally 3phase)

If your equipment is not covered by any of the product specific standards, use the Generic Standards.

8.13 Testing for Compliance

The testing of products so as to ensure compliance to the EMC directives is not easy. The fact that YOU are fully responsible for the declaration of compliance (a test house cannot do this for you) can be a daunting thought. Obviously, you can rely on external consultancies, but this strategy can be expensive and you gain non of the experience that may be very useful on future products. Doing as much work 'in-house' a possible can bring many benefits in terms of costs, timescales and the acquisition of expertise. However, the cost of specialist equipment necessary to do the work can itself be a major deterrent. This is where pre-compliance test kits can offer an acceptable solution.

The standards cover two main aspects of EMC, Emissions and Susceptibility. The Laplace test kits cover the Emissions aspects of EMC.

Emissions can be split into two groups: mains conducted and radiated emissions, both covered by Laplace kits.

8.14 Production testing

For any products produced in quantity to a standard design, the legislation requires the establishment of a testing regime to monitor and ensure that the product continues to comply to the standards. In other words, a single 'type' test is not sufficient.
These standards specify a requirement to ensure that statistically at least 80% of the product conforms to the limits with an 80% confidence factor. EN55022 and other standards give full details.
This requirement can be achieved by testing a specified percentage of random samples of the production on a pass/fail basis. The RF-Kxx test kits can provide a cost effective means of accomplishing these emission tests, particularly if the 'background' trace is made to act as a limit line. This limit line can be derived from a 'marginal' pass product or from calculated data input either as a series of nodes in the Windows ..Limit menu....file.... facility or via a spread sheet using knowledge of the test data file format.

8.15 Pre-Compliance testing

Pre-compliance test equipment is not intended to provide the complete solution for checking that products meet the standards. As the name suggests, the aim is to be able to measure and roughly assess EMC emissions performance before using a test house or more specialised equipment for the definitive testing.
However, there are circumstances where the use of pre-compliance test kits can be judged adequate to justify self-certification. <See section 8.11>

Laplace pre-compliance test equipment can provide reasonably accurate and reliable conducted emissions test results. This is because the kits use fully compliant LISNs, designed to meet the requirements of CISPR16 and which give a calibrated output. So, in terms of mains conducted emissions, these test kits are adequate to judge the compliance of your produce, within an error margin of typically ±5dB.
All our test kits include near field probes. These are essential for locating the sources or leakage paths of troublesome emissions, but cannot be used to judge far field radiation levels. The EN standards specify that compliance must be judged on far field radiation levels because only these measurements are repeatable in controlled conditions.
Far field measurements are where pre-compliance test kits can be prone to gross errors if attempting to measure absolute field strength.
The problem is not the really the equipment, but the environment.
In other words, even if you had a fully compliant, top-of-the-range analyser and antenna your results may still be grossly in error because:
(a) metal objects (e.g. steel building frames, filing cabinets) in the vicinity are causing reflections.
(b) Ground plane reflections.
(c) Antenna factor errors.
(d) Background interference.
Some of these error sources can be minimised by testing away from reflecting surfaces (literally in a open field or large empty car park), using a calibrated antenna and compensating for the antenna factor in software and measuring and then subtracting background interference levels. Even so,

variability of ground plane reflection, errors inherent in low cost antennas and practical limitations of antenna positioning will mean that error budgets of the order of 10dB would be appropriate. An effective solution to these problems is to use an ERS (emissions reference source) to quantify the errors due to the test site.
Testing in a shielded room is not recommended. Although background radiation may be reduced, internal reflections would make sensible testing impossible. Test cells lined with RF absorbent materials or GTEM cells are ideal, but these are expensive.

8.16 CISPR

This stands for *International Special Committee on Radio Interference* which is a technical committee set up by the IEC (International Electrotechnical Commission).
The function of CISPR is to define unified limits and measurement techniques that can be adopted by European and National legislation.
Most EN standards have CISPR equivalents or quote CISPR measurement techniques (e.g. CISPR16)

8.16.1 CISPR16

This is a document issued by CISPR which precisely defines many of the measurement techniques and equipments required by the EN Standards.
Example topics covered are:
* Full constructional details of the LISN to be used for mains conducted interference measurement.
* Receiver bandwidth to be used for all emissions measurements

9.0 Checklist

1. Check the condition of the SA1020 pre-amplifier battery
2. Check the Sweep Rate control is fully clockwise
3. Check the Baseline control is fully anti-clockwise
4. Check the zero frequency peak appears in the appropriate position
5. Ensure that the LISN attenuator is never in the 0dB position and the 150KHz filter is IN.
6. Check the analyser is working in its linear region by selecting the full frequency scan for the range in use (4.5MHz or 450MHz), switching the input 20dB attenuator IN and OUT and checking for 2 divisions movement.
7. If measuring emissions against a limit line.....take great care to ensure that the test conditions as required by the standards are meticulously observed.
8. Ensure the appropriate IF filter bandwidth is used.
9. All amplitude measurements must be made with the frequency axis ‘zoomed in’ to less than 1MHz/div (450MHz range) or 100KHz/div (4.5MHz range)
10. When using the RF200 always use it with the SA1020 pre-amplifier at the head.
11. When using the PC output, ensure the analyser Filter switch is OUT.

10.0 Troubleshooting

Symptom	Cause	Cure
Trace scrolls randomly on PC screen	Digitiser looses synchronisation with scan	Turn Sweep Rate control on SA450B fully clockwise
Intermittent and/or random peaks on trace	Pulsed or intermittent emissions from product	Use averaging or Peak modes under Calculate menu
PC fails to acquire any trace	Wrong COM port selected	Check COM port settings under PORT menu
Peak readings not as expected	Analyser input in compression	Add attenuation on input (use 20dB switch on input or insert external attenuator. Check peaks drop by corresponding level.
Peak readings not as expected	Settings on PC incorrect	Check attenuator, LISN, input type, antenna distance & pre-amp settings
Lower than expected signal level	Flat battery in pre-amp	Replace battery
Centre frequency display jumps in value instead of scrolling smoothly	Slow sweep rate.	Turn sweep rate control clockwise

11.0 EMC Declaration

DECLARATION OF CONFORMITY

We, Laplace Instruments Ltd

of

Tudor House, Grammar School Road, North Walsham, Norfolk,

declare under our sole responsibility that the product:

SA450B Spectrum analyser

SA1030 Serial interface

SA1020 RF pre-amplifier

to which this declaration relates is in conformity with the following standard(s) or other normative document(s)

EN50081-2
EN50011 Group 1 Class A
EN60555-2/3

Following the provisions of

EC Council Directive 89/336/EEC

North Walsham
8th January 1996

Signed.....

David Mawdsley
Managing Director.

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